A. TERPIGOREV

REMINISCENCES OF A MINING ENGINEER

ACADEMICIAN A. TERPIGOREV

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ВОСПОМИНАНИЯ ГОРНОГО ИНЖЕНЕРА

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To the Soviet youth, to my pupils, to all Soviet miners

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INTRODUCTION

Writing memoirs is both easy and hard. Easy because I have devoted about 60 years of my life to mining, witnessed many interesting events, come across many fine people and, therefore, have something to talk about. Hard because it is not always possible to separate the essential from the secondary. The haze of time dims many of the events passed through, and faces seen, some two or three score years ago. Another reason why it is hard to write memoirs is that the present illuminates the past like a searchlight and impels one to reappraise many facts of bygone days from the standpoint of today.

The idea of writing my reminiscences occurred to me seven years ago, on my 75th birthday. I promised at that time to record my recollections of the Donbas*—both new and old—as I had seen it over almost half a century. Later, seeing that I still remembered many events from other periods of my life, I decided not to confine my narrative to the Donbas. The persons, facts and events that came back to my mind constitute the fibre of this book. I am very grateful to Y. V. Dembo for his assistance in preparing these notes for print. Perhaps many of the things I mention here are not so significant, but it seems to me that the events which I relate might make it easier to understand the conditions in which progressive intellectuals had to live and work before the Revolution, and trace the progress of mining as a science and industry.

The history of Russian mining is such a fascinating chapter of our science and engineering that whenever we

* *Donbas* is the abbreviation for the *Don*ets Coal *Basin*, or Donets Coal Field.

read anything about it, we feel there is much more to be said. And yet, very little has been written to show the progress mining has made in past decades, especially the early period. These recollections are not meant as a substitute for the history of our mining, but to some extent they might make up for the deficiency.

In Soviet years, mining has developed into one of the most advanced and highly-mechanized branches of our socialist industry. The mines are veritable underground factories, beyond any comparison with the primitive pits that I saw decades ago. I well remember the old pits in which coal was mined by hand. The pick and mattock were the only "mechanical" implements. Crawling strenuously through the low galleries, men towed heavy skid-troughs fastened to their belts with thongs.

I think it is worth telling about those times so as to give a clearer picture of how far mining has advanced in our country. It is axiomatic that the more we know of the past, the better we can size up the present. But the trouble is that we do not always appreciate our vast achievements in mining since the advent of the Soviet era; we take them for granted.

That, however, is not my only purpose in writing these reminiscences. Our young people are accustomed to wide open roads into the future because the state, like a thoughtful parent, helps them to get an education and choose a profession. Formerly, things were different. It was very hard for me and many of my fellow-students to get an education. Young people, whose only concern is to properly fulfil their duty to their country, would do well to remember that. Those who read this book may come to set a higher value on their good fortune of living and working at a time when their people have already built up a socialist state, the first in the world.

Academician A. M. Terpigorev

PART ONE

CHILDHOOD

In the eighties and nineties of the nineteenth century Tambov differed very little from the small provincial town described by Lermontov in his poem *The Wife of a Tambov Treasurer*:

Tambov on maps calls forth one's pity;
It's just a tiny little dot.
Erewhile a godforsaken city,
Today it's quite a sight, god wot.
Three streets it has, both straight and broad,
Some street lamps and a cobbled road.
Two inns there are: one noble inn
Called Moscow, t'other named Berlin.
Four sentry-boxes catch the eye
With two policemen standing by,
Who will salute you, spruce and gay;
Relieved they are twice every day.
. . . . . .
In short, a jolly little place.

Tambov was a little town in which life dragged as sluggishly as in the other provincial towns depicted by Gogol. The only things that distinguished it were the fairs and charitable institutions and the trotters of the local squires.

In 1901, when I was finishing the Mining Institute, I found the following description of Tambov in the Brockhaus and Efron Encyclopedia:

"About 20 per cent of the houses are made of brick. There are 33 Orthodox churches, including one cathedral.

In 1897 there were 48,134 inhabitants. The town has 32 factories and mills employing 337 workers and producing 748,000 rubles' worth of goods (including a winery, a distillery, a brewery, two tallow boileries, two soap works, a steam flour mill, eleven windmills, three candle works and a sugar refinery). Tambov is famous for its hams and sausages, which are exported to capitals."

The encyclopedia also mentioned the noteworthy fact that in 1899 the allocation from the town budget for the schools was only half the amount set aside for the maintenance of the police.

Such was the town in which I was born in 1873 and in which I spent my childhood and youth. My father, Mitrofan Ivanovich Terpigorev, was assistant department head at the provincial exchequer. My mother, Sophia Vasilyevna Terpigoreva, *née* Yevseyeva, came from a gentry family.

Our family eked out a rather miserable living because my father lost everything at about the time of my birth. The last scion of an old aristocratic family, he was neither nobleman nor commoner at that time. It all happened because my grandfather, a wealthy landowner, had been deprived of his noble rank. It was quite a sensational case.

Grandfather, a man of stern character, was extremely severe even with his own children. He treated his serfs so brutally that his own children complained to the authorities and he was tried, sentenced to prison and, as I have already mentioned, stripped of his noble rank. He had several estates in the Tambov and Ryazan provinces. It did not take my father long, however, to squander the sizable property that he had inherited, and then our family lived like most Tambov families of lower middle class.

Father was gentle and kind by nature, but not towards his wife, whom he treated with selfish harshness. Mother suffered terribly and the atmosphere at home was most oppressive. In 1880 the family broke up. Father went to his brother's estate, and sponged on him. Seeing how hard my mother and sister had to work and how they stinted them-

selves in everything, I always tried to be helpful. I brought the water to our small flat, carrying it in buckets in summer and hauling it by sled in winter. Although only a small boy, I took pride in the economy thus achieved in our very limited budget.

We had to leave the house in which we had lived until my father's ruin and moved into a small wing of the house of my mother's elder brother. Our income was made up of whatever mother and sister earned by sewing, plus the small allowances mother received from her two brothers (10 rubles a month from one and 15 from the other). The money was barely enough to make both ends meet.

My uncle, in whose house we lived, was superintendent of a district hospital, and mother sewed underclothes for the patients. She used to sit and sew by hand for hours at a stretch, and all for a pittance: 7-8 kopeks for a shirt and 8-9 kopeks for a pair of drawers. My sister helped mother after school. All in all, we had about 30-35 rubles a month.

Speaking of the gradual impoverishment and degeneration of the gentry, typical of many Tambov families in those days, I would like to mention the stories of a writer who faithfully described that historical process. He was my relative Sergei Nikolayevich Terpigorev, whose penname was Sergei Atava.

It may well be that none but students of nineteenth-century Russian literature are familiar with the works of that distinguished author. But in those days his stories about landowners and post-reform conditions in the country-side were very popular.

Atava described the gradual improverishment and decline of the landed gentry in a series of sketches entitled *Pauperization*, which began to appear in *Otechestvenniye Zapiski* in 1880. These writings, which are his best, were undoubtedly autobiographical. Among his later works was *Disturbed Shadows*, a series of stories about serfdom. Atava had a gift for fascinating narration, and the dia-

logues in his stories were written with consummate skill; he was well familiar with the life of the landed gentry and described it in a humorous vein. M. Y. Saltykov-Shchedrin thought very highly of Atava's writings.

In his little-known sketch "The Deseased Writer," Atava recounts the interesting circumstances of his acquaintance with the great Russian satirist. It was in October 1879 that he brought the first instalment of his *Pauperization* series to the editorial office of *Otechestvenniye Zapiski.* "When I came back for an answer a week later," he recollects, "I talked to Saltykov himself." Atava relates the conversation as follows:

" 'Not bad. But give me at least one more story. I want to see your scope. It is a broad theme,' said Saltykov.

"The second sketch had already been written and I had it with me. I handed it to him and he leafed through it at once.

" 'Fine.... Fine.... How many will you have in all?'

"I replied that I couldn't yet say for certain.

" 'Anyway, keep on writing. By the way, I crossed out the word "Our" and left only "Pauperization." I also cancelled the subtitle "Notes on the Ruin of Landowners." It is more than the matter of ruin.'

" 'But won't the single word "Pauperization" look bald? What if we add: essays, notes and thoughts of a Tambov landowner?' I suggested.

"Saltykov agreed: 'Yes, that would be all right.'

"Thus the title was decided upon."*

This conversation indicates that S. N. Terpigorev's series was based on facts relating to the life of our family.

THE PARISH SCHOOL AND THE REALSCHULE

For three years, starting with 1881, I attended a local parish school, where I was taken on as a charity pupil. Besides studying, I did odd jobs to earn some money.

* S. N. Terpigorev. *Selected Works*, Vol. VI, 1899, p. 637.

I must say in all fairness that this school was not a bad one for those times. In fact, even compared with bigger towns, Tambov had quite a large number of educational institutions, although the authorities, as I have mentioned above, were not too generous about allocations for public education.

Towards the end of the century the town had a Gymnasium, a Realschule, a teachers' college, a seminary, two theological schools, a women's diocesan school (for the daughters of clergymen), a district school of the Progymnasium type, two women's Gymnasiums (private and state), parish schools, and an institute for the daughters of noblemen. All these schools were open mainly to the children of the nobility, landowners, merchants and officials.

The 9th Grenadier Regiment was stationed in Tambov at that time. Against the background of the town's humdrum life, this was a very exciting event. Whenever I recall the Grenadiers, I think of Chekhov's *Three Sisters*. When I was in the third form of the parish school, the regiment was transferred to Vladimir. The inhabitants saw it off in the manner described in Chekhov's play. Tambov looked desolate after the abandonment of the summer camp on the outskirts, where the regimental band had played twice a week to entertain the townspeople. Dreariness settled on the town again, and there was nothing to shake the inhabitants out of their drowsiness.

Tambov stretched for about three miles along the Tsna River. Only one street was planned fairly well; besides log houses it had some brick buildings, several of them two-storeyed. The traffic side of the street was paved. The unpaved side was intended for exercising trotters, grown on the stud farms of local landlords. Clouds of dust hovered over this part of the street in summer. Such was the town's main thoroughfare and you can well imagine what the other streets were like.

Tambov. General view of Zoya Kosmodemyanskaya Garden in Sovetskaya Street. In the background the building of the former Realschule; on the right Philharmonic.

The street lights (kerosene lamps) were deplorably inadequate. In Chastnaya Street where I lived there were only three lamps—one at each end and one in the middle. As the street was pretty long, and also very muddy, you can imagine how effective such "illumination" was. The parish school was near my home, so it was not much of a job covering the distance. Then I joined the Realschule—and got a real foretaste of the "delights" of Tambov life: the school was about six blocks away, and I often had to grope my way in darkness. In autumn the mud was sometimes impassable. The teachers were very strict about the "spiritual" indoctrination of the pupils and because of church services we had to make the hike twice on Saturdays and once on Sundays. On our way to church we amused ourselves by hopping from stone to stone to avoid the numerous pools of water.

In spring and summer, hundreds of boats scurried on the Tsna, Tambov's only adornment. Boating was the best and

cheapest pastime. I liked to go boating with my schoolmates. But I was particularly keen on fishing since I was seven or eight, and usually chose the most solitary spots along the bank.

There was a small ferry running between Tambov and Tregulayevo—a picturesque place with a big monastery about 12 miles from town. Townspeople went there on outings and picnics. Near by was a wonderful shady wood where we often went on a hike despite the objections of the monks. They were enterprising people and they built some nice summer cottages with attractive verandas in the neighbourhood of the monastery and rented them out to wealthy people.

While at the Realschule I earned about 20 rubles a month by giving lessons (a lot of money in those days). I used to hire a boat for the summer and row to Tregulayevo alone or with a friend, several times a week.

On three sides of Tambov there were densely wooded hills protecting it from winds. Snow-falls were heavy but we children delighted in them.

The climate was damp and malaria was a widespread disease. I remember being laid down with fever for several months during my first year at the Mining Institute. That was the result of my going to Tambov for the holidays.

About two miles from Tambov there was a racecourse where people gathered from all over the province. I remember how we youngsters used to sneak in without a ticket and watch the thrilling races. It was great fun.

Tambov children had many other pastimes. One, which I recall with pleasure, was to go to the market-place. Market days were like holidays to us. We snooped into every corner of the market, but what attracted us most of all was the row of eating-houses. There we watched the cooks frying, boiling and steaming all sorts of dainties: liver, sausages and pea pies. In summer the fruit-stands were heaped high with berries. In Tambov there were fruit trees

in almost every garden. The biggest orchards were in our neighbourhood. They were a good source of income to the owners, who besides pears and apples grew melons and lots of berries. We boys naturally raided the orchards.

Actually I grew up neglected, for my mother and sister were too busy to pay much attention to what I did in my spare time. As soon as I got home from school, I would join the boys in the street and we would have lots of fun, playing *gorodki* or *kazanki*. There was only one criterion of a boy's prosperity: whoever had the most pig knuckles was the richest. We also chased around the street playing *lapta*, so that by the time I got home in the evening I was pretty well worn out. We had the best time in summer, of course.

I was also fond of catching birds. I cleared up part of the large garden adjoining our house and caught goldfinches, tomtits, siskins and bullfinches with the aid of various kinds of nets and bait. I kept several cages in the house and was hurt when mother or sister showed their displeasure. If the birds sang, I kept them through the winter; if they did not I let them out. In Tregulayevo, where my uncle used to go for the summer, I liked to pick mushrooms in the woods.

All my life I have loved catching birds, mushroom-picking and fishing. Even today there is no recreation I like better than picking mushrooms in the woods around Moscow and fishing.

My years in the parish school left a deep impression on my mind. I vividly remember our teacher Bystrov. An excellent instructor, he taught us to love Nature, to strive for knowledge, to interest ourselves in all that went on around us. Perhaps it was those early impressions that later influenced my choice of profession.

Bystrov was not like the other teachers, who thought their mission did not go beyond the official curriculum. He tried to teach us to understand Nature and often took us on outings. With knapsacks on our backs, we would tramp

several miles to one of the groves outside the town. Bystrov loved his pupils, was patient with them and never resorted to corporal punishment, as did many of his colleagues in those days. The pupils, too, were fond of their teacher and never played any tricks on him. Thanks to his active teaching method, we learned to read and write very quickly. Furthermore, Bystrov was an excellent elocutionist. In the second and third forms we could sit for hours listening to him reading fragments from the works of Pushkin, Gogol or Turgenev. All this helped us to study faster and better. Bystrov eventually gave up teaching to become a notary in the town of Kozlov. When, as a student at the Petersburg Mining Institute, I came to visit my folks, I often dropped in to see him.

Our parish school was the youngest in the town, but we knew that it had a good record and were proud of it. Those who finished it generally had no difficulty in entering the Realschule or the district school.

My childhood and carefree life ended soon after I was enrolled at the Realschule.

In my first years there I continued to spend much time outdoors. But when I passed into the fourth form a big misfortune befell our family, and my life changed. Forced to overwork, my mother contracted consumption, and I had to help out by giving lessons to backward pupils. Life became harder, there was practically nothing joyful in it.

Generally speaking, I was a lively lad, but I was well-behaved from the first form on, and studied well. When I passed into the second form I received several prizes: a testimonial, a set of drawing instruments for my good drawings, and a book of stories by Russian authors. The story that impressed me most was Dostoyevsky's *The Boy at the Christmas Party*. After the presentation ceremony, I handed the prizes over to my mother who loved me very much, and she broke into tears.

"Why are you crying?" I asked.

"From joy," she replied.

After mother's death I stayed at my uncle's for a whole year, coaching his children. Later, he had me accommodated in the Naryshkin Boarding-House for Gymnasium and Realschule pupils, where, in return for my board and lodging, I had to coach ten or twelve pupils daily. There I spent my last three years at the Realschule.

I knew very well that henceforth I had no one to rely on except myself, that I could win a place in the sun only by my own effort, and I dreamed of getting a higher education.

I got permission to give private lessons elsewhere and every day, immediately after dinner, I hurried off to my pupils. That was at about three o'clock, when all the other students could play. I usually returned at half past six, and had to begin lessons at once with my permanent group. This lasted till almost 9 p.m., and it was only after supper that I had a little time left to do my own home work because we had to be in bed by 11 o'clock. And so it went on, day in and day out, for several years.

I spent the summers on the estates of Tambov landowners, preparing their children for autumn re-examinations. By working hard I managed to save about 600 rubles—a big sum in those days. It enabled me to go to Petersburg to enter the Mining Institute.

I will always remember those summer trips to the country. There were woods and a river—the scenery was beautiful, but I had to sit for hours with spoilt and lazy children. I felt very lonesome there and spent all my free time hiking, which gave me a chance to learn more about Nature.

As I have said, my love of Nature, which was born in my parish school days, determined my later choice of career. Another important factor was the method of teaching natural sciences in the Realschule.

During my seven years in the Realschule (1885-92), I studied botany, zoology, physiology, chemistry and geology, including mineralogy and crystallography, rather ex-

tensively. V. P. Yegorovsky, who taught these subjects, loved natural sciences and passed that love on to his pupils. His method was lively and fascinating and we liked his lessons more than the others. Although it was not the accepted form of instruction in those days, he gave a lot of attention to practical studies. He always brought various minerals, plants, etc., which he had collected himself, to the class-room, and used other visual aids. This naturally made learning easier. But even more important, perhaps, was the fact that Yegorovsky imbued his pupils with a sense of direct contact with Nature. In the stifling atmosphere of pedantic indoctrination of that time, his methods were indeed new and refreshing. They left a deep impress on our young hearts. Sometimes he took us on long walks into the country. There we scouted among the reeds along the river-banks, collecting plants and insects, which we later dried, mounted and classified. We often made interesting experiments in chemistry at the homes of some pupils, for in school we had neither time nor place for that. From our country excursions we always returned satisfied and refreshed.

Though there were good and competent teachers in the Realschule, very few of them used such stimulating methods of instruction.

Beginning with the second form we studied foreign languages—first German and then French. The lessons were well conducted. Our teachers—a German by the name of Johannson and a Frenchman by the name of Ley, were determined to make us learn both the spoken and written language. On the whole they succeeded, even though we waded through the lessons without much heart.

A teacher who appealed to us all was A. V. Proskurnikov. His subjects were the Russian language, geography and history. He taught us to appreciate our native language and history. At geography lessons he spoke enthusiastically of Russia's boundless expanses and vast resources.

The building of the former Realschule, Tambov

I had top marks in all subjects except grammar. To improve on it I began, in the fourth form, to take additional lessons from my teacher. He himself suggested to tutor me free of charge. He dictated fragments from Russian authors and then analyzed my mistakes. I soon caught up with the best pupils.

Teaching methods in mathematics were very good. In the first six forms we took a general mathematical course, and in the seventh studied the fundamentals of differential calculus, higher algebra, cosmography and descriptive geometry (the latter we began in the sixth). Much attention was given to draftsmanship, which came in place of drawing in the sixth form. By the way, the drawing lessons were also well organized. We drew from life in pencil, ink and water-colours. We also sculptured. Such instruction in the arts helped to develop the aesthetic taste of the pupils.

The experience I acquired in drafting was helpful in my

further studies at the Mining Institute and later, when I worked as a mining engineer.

Generally speaking, the Realschule offered more practical experience and sounder knowledge in the exact and natural sciences than the Gymnasium, where more attention was paid to Latin and Greek. In our school theoretical studies in the exact and natural sciences were combined with practical training whenever possible. In the sixth form, and especially in the seventh, we did many problems in geometrical construction, learned to build triangles, trapeziums and other geometric figures out of given elements.

At the Naryshkin Boarding-House regulations were strictly enforced. We rose at seven thirty and went to the assembly hall for morning prayer. Incidentally, too much time was devoted to spiritual indoctrination. We were bored by catechism, compulsory attendance of church services and strict observance of fasts and sacraments. On Saturdays the service began at six in the evening and lasted for at least two hours. On Sundays, holidays and "crown" days we had to attend mass. Every morning, before breakfast, the pupils lined up in pairs and went to prayer. While the priest read a chapter from the Gospel, the pupils amused themselves as best they could, but so that the teachers would not see.

Lessons began after breakfast and continued till two. Dinner was at three. The time from three to five was set aside for games in the courtyard. After five the pupils did their home work under the supervision of teachers. Supper at nine was followed by prayer and then came bedtime. The pupils would gladly have spent more time running about, playing and reading, but they were always under the vigilant eye of the teachers. Practically every step was regulated by stern rules. It is true that Soviet schools today also attach much importance to the pupils' behaviour, but there is not a trace now of that cold, absurd formalism that pervaded the Realschule rules of conduct.

The wise men who had made the rules strictly prescribed how pupils should conduct themselves if they had the misfortune of meeting some important person in the street, say, the district trustee, the governor or the bishop. Moreover, they were forbidden to go to places of amusement or to public libraries, and even to subscribe to magazines and books. Education was thus kept within legal, official bounds, so to speak. Determined to make "upright" citizens of the pupils, the compilers of the rules forbade them categorically to "form any societies among themselves or in association with outsiders, or to join such societies, the penalty being prompt expulsion from the school," or to participate in public ceremonies in honour of anyone.

It was only the pupils' thirst for knowledge, plus the qualities of some of the teachers, that kept alive the urge to study in such conditions.

My class was lucky. Our master, Yegorovsky, taught natural history, physics and chemistry, and it was our good fortune that he gave more of his time to these subjects than to watching our behaviour or investigating our misbehaviour.

As I have already mentioned, he even organized laboratory experiments. Our physics laboratory was pretty well equipped. All the pupils, including myself, took turns in assisting him. It is always with pleasure that I recall those days.

The years flew by in swift succession. In the spring of 1892 I finished the Tambov Realschule with honours. Long before that I had begun pondering what profession to choose and where to continue my schooling. It was beyond question that I had to get a higher education. In the Realschule I had acquired faith in my capabilities and felt sure I could overcome all difficulties and get what I wanted.

According to regulations then in force, Realschule graduates were not admitted to universities; only Gymnasium graduates were eligible. Consequently, I had to choose one of the specialized institutes. But which one?

Nowadays, under the socialist system, it is easy to find the answer to this question, which confronts many thousands of secondary-school graduates every year. It is easy because nowhere in the world is so much care and consideration given to the education and training of the youth as in our country. The state is always solicitous and helps boys and girls to choose a profession. I have had occasion to observe that at the Moscow Mining Institute. Each year, long before they pass their finals, youngsters come to our auditoriums and laboratories to learn about our Institute, the subjects taught, the kind of training it gives. Our leading professors and teachers help boys and girls to map out their life. And so it is in the hundreds of other institutions of higher learning throughout the Soviet Union.

Instruction in the secondary school also conduces to proper choice of profession.

In my day, when I graduated from the Realschule over sixty years ago, things were entirely different. I had no one to help me to choose a speciality. I can now say that I did not make a mistake.

I wanted to specialize in the natural sciences, to study Nature, and to be an engineer as well. Such training was offered only by the Mining and Forestry institutes in St. Petersburg. When I learned more about them, I found that the subjects I liked most—geology, mineralogy and chemistry—were taught at the Forestry Institute in far lesser measure than at the Mining Institute.

So I chose the latter.

PREPARING FOR THE INSTITUTE

All my life I will remember the summer of 1892. Besides coaching, I was busy those months preparing for the entrance examinations. The procedure of entering an institute in those years would seem strange to the student of today. What preoccupied our minds as we burned the mid-

night oil was not so much the meaning of physical, mathematical or chemical laws and not so much the problems we would have to solve, as the thought of what snags we were likely to encounter in the course of the entrance exams.

The examinations were a kind of contest between the stern and wily professors and the examinee, who had to display maximum self-control and composure to wind his way through all the "underwater reefs" of crafty interrogation.

I will never forget the day of my arrival in St. Petersburg. It was my first visit to a big city, and not just a city, but the capital.

Before me stretched long straight streets, tall buildings, the Bronze Horseman (as the monument to Peter I is called), and the golden dome of St. Isaac's Cathedral. I roamed the streets for hours, admiring the magnificent architecture. Imagine a provincial who had known no better pastime than knocking about the town market or going fishing, and you will realize how I felt on coming to St. Petersburg.

Three of my Tambov friends and I rented a room without much trouble. Two of my companions also intended to enter the Mining Institute. The morning after our arrival we headed for the Institute, our hearts thumping, and called on assistant inspector Tsitovich. He received us rather coldly. We provincials were tongue-tied with excitement, and he directed us in an offhand manner to the assembly hall where everything was ready for the first exam in the Russian language. We had to write a composition on the wise old saying "All is not gold that glitters."

As soon as we learned about the theme we felt that our prospects were bleak. Moreover, we had heard just before the examination that there were almost twelve applicants for every vacancy (afterwards we discovered that as many as 330 persons had taken the exams for the thirty vacancies).

It did not take us long to realize that the tricky theme had been selected deliberately to eliminate as many persons as possible in the very first exam.

When I completed the composition I was quite sure there was no hope of getting the highest mark. To my regret, I was right. Greatly worried, we went to take the second written examination, in mathematics. Before it began, Tsitovich read out the marks for the composition. Many applicants failed, many others just managed to pass and very few got good or excellent marks. I was among those who had just managed to pass, but that delighted me more than an excellent mark would have at the Realschule. Despite the very modest rating of my ability, I was glad and even elated; I had surmounted the first obstacle and cleared the road to other tests.

The remaining exams—mathematics (written and oral), physics and foreign language—did not trouble me very much. Indeed, I scored 23 points out of 25.

You can imagine my joy when I saw my name among the thirty lucky persons admitted to the Institute.

Do not think, however, that only thirty were enrolled and that all the other applicants (many of them sons of influential persons) remained on the other side of the fence. Besides those admitted after competition, about as many more were enrolled additionally on the instructions of the Minister of Agriculture, who exercised jurisdiction over the Mining Institute. This gush of "gilded youth," which swamped the first-year course, washed us, poor provincials, into the background. But I must say that the democratic-minded students were quick to unite in a close-knit group.

We had only a very faint idea as to where we might get a job after graduating from the Institute, and what the conditions would be like.

Now, in Soviet times, the problem of employment does not arise before the graduates. Constructive work in all spheres is developing on a grand scale. Within a few

weeks young specialists are provided with employment, which affords them all the conditions needed for fruitfully applying the knowledge they obtain in the higher educational institutions. Our socialist national economy requires increasing numbers of specialists, therefore the problem of jobs sounds absurd.

A. M. Terpigorev, first year student, the St Petersburg Mining Institute

In capitalist Russia, this problem was very acute. We knew that no one was expecting us after graduation and we had no assurance whatever of finding a job. Neither in the first nor in the following years of study had we any real notion as to what mining education held in store for us. The "aristocratic" students looked at the thing from an entirely different angle. They did not have to worry about their future. That is why they were lukewarm to their studies and indeed tried in every way to shirk the tasks set them by the professors and teachers.

The nineties and the early years of this century saw the birth of the working-class movement in Russia and the formation of Social-Democratic organizations. Revolutionary-mined students took an active part in the movement, incurring cruel reprisals.

Class differentiation among the students naturally influenced their political frame of mind.

Illegal circles cropped up among the democratic students at our Institute, as well as at other higher education-

al institutions of St. Petersburg. They circulated Social-Democratic literature and hectographed leaflets of revolutionary content. It goes without saying that such underground work was extremely dangerous and entailed most unpleasant consequences.

Imprisonment and exile were the penalties paid by many students for their illegal activities. This was the lot of some of my own close associates in the third year. One night my room was searched and I was ordered to report promptly to a police station. There I was interrogated but got off rather easy, for the gendarmes had no evidence on which to prosecute me or deport me from St. Petersburg, and the whole matter ended with their putting me on the list of unreliables. This caused certain difficulties in finding employment after I graduated.

Class differentiation among the students found visible and, I would say, symbolic expression in the way they placed themselves in the smoking-room, which was also a sort of club-room.

Our comparatively small but homogeneous group of provincial students, dubbed "the Lefts," always occupied the left side of the smoking-room. The "white lining group," as the reactionary-minded students were called, shrouded themselves in smoke on the right side of the "club." The division corresponded to the way seats are divided in parliament. And, as in any "respectable" bourgeois parliament we also had a "centre" whose members were called "opportunists"—a new term at that time. They tried to side with neither of the two main groups. The guiding role in the life of the Institute belonged to the group in which the Social-Democrats enjoyed influence. When students gathered in the club-room during the short recesses between lectures to play a game of chess, read a newspaper, exchange an illegal book or simply to debate some point concerning the students' social life, the biggest crowd was usually on the left side of the "club."

The democratic group co-ordinated the work of the vari-

ous voluntary student societies. It virtually directed the activities of the Library Committee, the Mutual-Aid Fund, the Mess Committee and the Red Cross Committee. Besides conducting open, legal activities, some of the committees carried on underground work.

Thus, strictly divided into groups of different social standing, we began our first year at the Mining Institute.

THE ST. PETERSBURG MINING INSTITUTE

The St. Petersburg Mining Institute was one of the foremost institutions in tsarist Russia so far as the system of instruction was concerned. Nevertheless, instruction, as well as all other activities, were pervaded with the formalism characteristic of those days. Many of the teachers, especially in the junior classes, were utterly indifferent to what the students learned.

Regulations on how to wear the student uniform were very stringent, and were often taken more seriously than requirements pertaining to knowledge.

I should like to point out another detail which I think is likewise indicative of formalism. The Institute authorities were very strict about attendance at lectures. But the way they registered the students! Before each lecture an assistant inspector carefully examined the pegs in the cloak-room. If there was no cap on a peg, the student was considered absent and faced serious consequences. If the cap was there, the student was registered as present. The students soon found a way of circumventing this peculiar system—to the benefit of the cloak-room attendant. He kept his own supply of student caps and hung them on the pegs of his "clients" for a modest remuneration. After the lecture the caps were removed. Formality was thus observed, and the student was free to do as he wished. Small wonder that some of the less popular lectures were attended by not more than 8-10 students. But even these attended by prior agree-

ment with their fellow-students—after all, someone had to attend!

So began my first year at the Institute. First I had to order a uniform, pay the tuition fee (which was 60 rubles for the first year) and find suitable board. I had not much money, therefore it was rather important to find a cheap and good eating-place.

The most suitable was the restaurant run by von Derwis, who helped students quite a lot. There you could get a fairly good dinner for 15-20 kopeks, and it was there that I had my meals during the first year at the Institute. Meagre as my resources were, I was able to make both ends meet. Later, when I was in my fourth year, the Institute opened its own mess-room and that, of course, was a great event. Inspector A. M. Loransky, who always treated the students well, helped to find the necessary premises and to get the mess-room running. I happened to be one of the first chairmen of its committee and remember how important it was to us, for, besides providing us with cheaper and better meals, it also saved us a lot of time. This was especially valuable for the students of senior courses engaged in planning, designing and laboratory work. They could now stay at the Institute from early morning till about 11 p.m.

The excitement and keen interest with which we freshmen looked forward to Professor G. A. Timé's lectures on analytical and descriptive geometry was quite understandable. True, the lectures were rather dry and did not arouse any particular desire to go into the subject thoroughly, but their content and the simplicity with which they were delivered were really praiseworthy.

Our class showed the greatest interest in Professor P. V. Yeremeyev's lectures on crystallography, and in the lectures on chemistry, delivered first by Professor V. F. Alexeyev and later by the outstanding Russian chemist N. S. Kurnakov, who later became an academician.

Crystallography was considered a not-very-engaging subject, but Professor Yeremeyev delivered his lectures so skilfully that we all listened with rapt attention. It soon became one of our most favourite subjects. Professor Kurnakov's lectures were pithy and lucid. It was in our first year that the young Professor first began to teach. The students' relations with the other teachers were purely formal, but in the case of Kurnakov they developed into real friendship. We often crowded around him after the lecture and showered him with questions. We liked Kurnakov because he tried to make his lectures interesting and always accompanied the theoretical course with interesting demonstrations and experiments.

Moreover, Kurnakov was one of the first professors to insist that students should delve more deeply into subjects by studying independently. At that time the higher educational institutions hardly gave any attention to independent work, in particular research, by students. Professor Kurnakov worked out a new method. For example, he gave my fellow-student Znamensky and me an assignment to write a paper on Mendeleyev's Periodic Table. We were thus impelled to study that part of the course more carefully, to read books and other material which we otherwise would not have done.

During the first year we studied somewhat sluggishly, our sole aim being to find the easiest way of preparing for the exams. We therefore made no attempt to study any curricular subject thoroughly.

Unlike the other lectures, those on theology were a conglomeration of scholastic definitions. And while the other examinations presented no serious difficulties to me or to anyone else, the exam on theology was torture and I almost failed.

At the beginning of the second year things took a turn for the better. As a needy student making good progress, I was granted an annual scholarship of 300 rubles.

The Mutual-Aid Fund was an appreciable help to us students. It was made up chiefly of proceeds from concerts and dancing parties. Such parties, with sale of champagne, etc., were generally got up by well-to-do students, who prided themselves on their charity work. Democratic students got up refreshment bars and most of the proceeds were turned over to the Mutual-Aid Fund, and also to an illegal relief fund for political prisoners.

Since these seemingly innocent parties had a definite revolutionary purpose, only the most trusted were elected to the special refreshments committee.

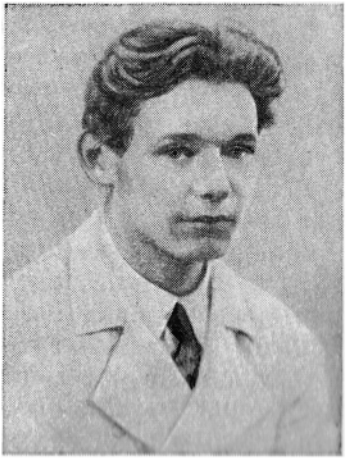
As I have said before, there were both legal and semi-legal student organizations within the Institute. Its authorities pretended not to notice their activities and that, of course, suited us fine.

Committees met either in the smoking-room or a vacant auditorium. The books of the student library had to be kept in private homes. Every morning some of them were secretly brought to the Institute and quickly distributed according to lists drawn up in advance. Towards the end of the first year I was elected a member of the Library Committee and was entrusted with the history and sociology section, in which there were about one hundred books, including latest editions. A small fee was charged to the readers.

The students had the interests of their country at heart and therefore took part in the revolutionary movement. A major event that I remember was a student demonstration in Kazan Square in March 1897, shortly after the tragic death of M. F. Vetrova, a student in the Higher Women's Courses in St. Petersburg. She was arrested in 1896 for revolutionary activities and confined in the Peter and Paul Fortress, where she committed suicide in protest against the humiliating prison regulations. The demonstration was preceded by meetings in the Institute, at which the students denounced the police regime and unanimously decided to take part in the manifestation. The students

who gathered in Kazan Square and the adjacent streets were dispersed by the police and Cossacks. Many were brutally whipped and some arrested.

That powerful demonstration, in which the students displayed their strength and voiced their protest against the tsarist autocracy had tremendous repercussions. Hundreds of students, including some from our Institute, were persecuted, deported from St. Petersburg or deprived of scholarships.



A. M. Terpigorev, student of the St. Petersburg Mining Institute

That was about the time when illegal student circles began to study Marxism, chiefly *Capital*. However, students engaged above all in cultural and educational work; they collected books and sent them to the country-side, taught workers at evening classes, and organized student fraternities. At their parties and gatherings they often held heated discussions.

At the Institute a good deal of attention was devoted to the natural sciences, although there was not much differentiation of the special branches. A student's specialization was based on descriptive courses and elementary practical training. In former years there was no division into narrow specialities. I myself studied the full range of subjects relating to metallurgy, mining and mining mechanics.

My diploma work covered four subjects: mining, mining mechanics, metallurgy and building.

Even in the senior classes laboratory work was restricted to analytical chemistry and assaying. There were no preliminary or periodic tests.

Examinations and the drafting of projects were the only check-up. Incidentally, no time was set aside for projects in the curriculum and we worked on them in our free time, with very little advice from the teachers. What we got from the lectures was chiefly descriptions of devices and equipment, sets of figures, and empirical formulas of certain physical and chemical processes.

Although preliminary exams were not customary, most students took them voluntarily in the subjects they liked most (such as palaeontology conducted by Professor I. I. Laguzen, or structural mechanics, conducted by Professor F. Y. Maximenko) because it made things much easier at the regular examinations. Professor Laguzen used somewhat peculiar methods in teaching palaeontology. To pass his examination, a student had to identify animals by the fossils of palaeontological collections. If he did so accurately and quickly, his rating was excellent. Some students learned to recognize minerals simply by touching them, with their eyes shut.

The study of special subjects was a tedious matter and most of the lectures were boring. Of course, there were talented men among the professors and teachers, but teaching was done scholastically. That spirit prevailed in the higher schools till the late nineties. We were fortunate to have teachers who tried to stimulate our urge for knowledge and presented their lectures cogently and vividly. One teacher whose train of thought never followed directions from above and who always searched for new methods was Professor I. V. Mushketov. His lectures on physical geology were graphic and colourful, and always drew large audiences. This subject was taught to third-year students, but our younger colleagues also came to listen.

We never forgot the very interesting lectures on historical geology read by A. P. Karpinsky, one of the great Russian scientists, who later became the first elected President of the Academy of Sciences. At that time he was the only academician in the Mining Institute. Students were

attracted to his lectures not only because he was an outstanding scientist whose work—*An Outline of the Physical and Geographical Conditions in European Russia in Past Geological Periods*—they all knew well, but also because of his charming personality, good-naturedness and gentle manner, which distinguished him from other professors.

Professor I. A. Timé's lectures on mining engineering, too, were eagerly attended. They always kept abreast of scientific and technical developments. He was the only professor who allowed the students to use their own compendiums at examinations, for what he wanted them to do was to understand the essence of laws and phenomena, and not just to memorize the laws of mechanics.

MY INITIAL PRACTICAL TRAINING

In the summer of 1895, after completing my third year, I went in search of a temporary job to the Sulin settlement in what was then known as the Don Army Region. Inhabited mainly by Don Cossacks, it stretched along the middle and lower reaches of the Don. There, in the mines of the well-known iron manufacturer Pastukhov, I first saw how hard miners had to work under the capitalist system.

Two years earlier, when we finished our first-year course, we were sent for summer practice to a village near St. Petersburg. Broken up into groups, we engaged in geodetic survey. What I remember about that expedition is not so much the work we did as the environment. In the village of Rozhdestvenskoye we rented two small rooms. Fieldwork began in the morning and lasted till two in the afternoon. One of us stayed at home to cook dinner. Since none of us knew much about that, the meals left much to be desired. After dinner we rested till five and then worked till eight or nine. This continued for a month. Practice in the open refreshed us and improved our health, and this was one of the positive results of the expedition.

The second term of practical training was more serious. We went through a good many mills and factories around St. Petersburg, some of them world-famous at the time, such as the gunpowder works, the porcelain factory, and especially the Obukhov Cannon Factory. We also visited peat bogs.

It was then, too, that we first saw how iron and steel shops worked. We were cordially welcomed in the mills and readily acquainted with the "manufacturing secrets" —a very rare thing in those days. This time the whole class, led by a professor, visited the mills, staying there from 9 a.m. to 5 p.m.

Since a good many of my fellow-students were sons of rich noblemen, big landowners or high officials, mill managers affected great hospitality and often gave pompous dinner parties for the students.

Our visits to some of the bigger Russian factories gave us future engineers our first knowledge of the manufacturing business, and I must say that it was very valuable.

When the third summer came around, I went to get some real practical experience, not as an excursionist, but as an employee of the Pastukhov Works. My job was to explore for limonite, and it gave me a chance to take a good look at the mines and ironworks.

The Pastukhov Ironworks was one of the oldest in the South and needed large quantities of limonite, mined near by. Its owners leased from the Cossacks and landlords of the Don Army Region huge tracts of land stretching to the north and west of the works, in the vicinity of the Donets Railways between the stations Zverevo and Krestnaya (now Shterovka). Contracts with the landowners gave the proprietors of the works the right to mine any amount of iron ore at the price of one-fourth of a kopek a pood [about 35 lbs.—*Tr*]. And since a lot of ore was mined, the Cossacks had a sizable and, what is even more important, steady income.

The limonite obtained in these mines contained from 35 to 42 per cent of iron. The ore occurred in small nests or pockets. When I arrived in Sulin, those close to the works had already been exhausted. My task was to prospect for ore farther away.

I tackled the job with my friend V. N. Weber (later a professor at the Mining Institute).

I learned all about the Pastukhov Works before setting out. It consisted of a small smeltery with only one blast-furnace using anthracite brought from the Grushevsky District, a puddling shop, a big machine shop, a foundry and rolling mill, a small brick-kiln and several subsidiary enterprises. Near the works were quarries supplying building materials (stone, sand and clay) and at a short distance, deposits of limestone and iron ore, which were extracted from inclined pits.

All the shops except the blast-furnace shop consumed local anthracite. The technological process was based on the use of local fuel.

It was then that I saw how different the working conditions of the ironworkers and miners were from those described to us at the Institute, how hard and cheerless their labour was.

One of the reasons was that the employers did not want to spend any money on labour-easing facilities or on improving sanitation.

The Sulin Works, whose numerous buildings lay on the slope of a large hill descending towards the South-Eastern Railway, presented a picturesque sight, particularly on summer evenings. Brilliant sparks lighted up the dark sky when metal ingots were carted from the heating furnaces to the giant hammers for shingling or when they were put through the rolling mills. As strips of white-hot metal threw sheaves of sparks about them and molten metal flowed into huge ladles like dazzling liquid fire, you could see workers' silhouettes moving about against the

background of the night darkness. I was never tired of watching the fascinating scene.

I closely examined the iron mines in the neighbourhood of the works. My purpose was to learn to locate ore deposits by outer indications. To be suitable for smelting, the ore had to contain at least 35 per cent of iron. This art, naturally, could not be mastered at once. I gradually familiarized myself with the nature of ore occurrences, the distribution of limonite nests and the various mining methods. These nests, rather small, were embedded side by side with limestone or sandstone deposits and were usually about 300-500 metres long.

Miners worked each nest separately by driving an inclined shaft outfitted with very primitive equipment. The ore was usually hoisted by hand or, at best, with the aid of a horse gin. An airway was driven from the shaft for ventilating the workings. There was no need for drainage because the ore beds were dry. The miners had to work under extremely hard conditions—utterly unthinkable today. The owner of such a tiny pit, which the people aptly called "a mousetrap," usually lived in a small, one-window mud hut, with eight, nine or ten miners. A primitive, miniature mine like that was as a rule worked in winter, when the men were free from farm work. Heavy snow-drifts, quite frequent in those parts, often handicapped operations, and it is only natural that the output of such dwarf mines was very small.

After studying the prospecting plan, I left for the site of my job or, to be exact, for the house several kilometres away from the deep gulches where outcrops of iron ore were likely to be found. Lumps of ore accumulated at the bottom of such a gully served as a natural indication as to where to look for the nest. My friend Weber came just as I had begun the survey, and we continued the search together. Weber and I would walk along the two slopes of the gulch, marking the spots where there were signs of deposits. In this primitive manner we explored almost every

inch of a huge tract of land about 80 kilometres long and 20 kilometres wide. To understand the difficulty of our job, one should bear in mind that modern prospecting methods and devices were entirely unknown in those days, and we had nothing but our hands and eyes to search with.

We did not overlook a single gully, usually covering 20 kilometres a day, invariably beginning at sunrise and winding up at sunset. Sometimes we came upon iron or anthracite pits. I then got some idea of the labour conditions in those very small mines.

A few of the anthracite pits were located near the railway stations Dolzhanskaya and Krestnaya. Near the first of these two stations were the well-known pits owned by Korneyev, Rakhmanin and several other smaller operators. The most valuable grades of anthracite were obtained from the 1st and 2nd Dolzhanskaya seams, which were more compact and firm and did not crumble from exposure. Anthracite was extracted in slabs and large lumps. Another of the best anthracite beds was the Khrustalsky, near Krestnaya.

We prospected at the inclined workings of some of the small anthracite mines near Dolzhanskaya. While investigating the gulches in the area, I learned much about the mines operated by Korneyev and Rakhmanin, if mines they could be called, for they were a far shot from what that name implies now. There were none of the usual head frames by which we now recognize a mine a score kilometres away. All that marked an anthracite pit was a few small surface structures, and it was only when you came closer that you realized it was a mine.

Near the one-storey shaft house built of local sandstone were several auxiliary structures and a few small houses for the technical personnel, who usually included one or two head miners and several office employees. Not far from these houses were barracks for the miners. The thing that struck me first was the inadequacy of living quarters for the seasonal workers, most of whom were peasants from

the Tambov, Orel, Ryazan and other Central Russian provinces. There were also quite a few Tatars from Kazan Province. The barracks accommodated only a small number of miners, and despite lack of space—there were rows and rows of bunks—and the heavy stench the miners regarded them as a luxury.

We learned where the rest of the workers were housed when we were examining a gulch near one of the mines. We saw on the slopes dozens of tiny mud huts half-buried in the ground. They were for miners with families. The squalor was staggering. The pit dwellings were built close to one another, the cluster making up a kind of isolated settlement. The miners called these settlements "dog pounds," for the shanties looked more like dog kennels than human habitations. The mine operators did not give the least thought to the welfare of the people, all the more since labour in those days was very cheap, and they squeezed everything they could out of the workers.

I will never forget those dwellings. They all seemed to have grown out of the slopes or spurs on which they were built. The walls were of sandstone slabs, coated with clay on the outside, and sometimes on the inside, and whitewashed. Three of the walls were blind, the fourth had a door and a window. There was neither floor nor ceiling. The roof was made of thin slabs of clay slate and let the rain through.

In the barracks for single workers there were two-tiered bunks and the men usually slept on bare boards or, occasionally, on thin straw mattresses, huddling together to keep warm.

Needless to say, the workers had no idea what recreation meant. Indeed, how could they, having to work underground for fourteen or sixteen hours? Slave labour sapped their strength.

When I began prospecting, my first desire was to see underground workings. The techniques which I saw in the anthracite pits nearly sixty years ago prevailed until the

advent of Soviet power and were typical of the average-type mines throughout Russia. The Soviet miner would find it hard to imagine how primitively coal was mined in those days.

It stands to reason that with such antiquated techniques productivity was very low. In an anthracite pit a shift never produced more than half a ton. In those days they used to say "per team" and not "per shift."

The head miner eventually gave me permission to go down into the mine (he was the only technician who had the right to do so), and I was accompanied by a foreman to the shaft top works where cages bringing up tubs of anthracite were hoisted up. The shaft collar was also used for lowering timber and other materials into the pit, and for taking miners up and down. The cages were raised and lowered by a small steam hoist installed in a special engine-room next to a small boiler-room, usually containing not more than three boilers. The door of the hoisting compartment was opened automatically by the cage itself. Near the landing stood a cageman who ran the cages up and down by signalling to the engine-room.

You may well imagine my delight when I finally got into the cage. Along with a few words of advice I was given a small oil lamp. These lamps, called "Godspeed," were of psychological rather than practical value. With lamps out, we descended blindly to the main level connected with the shaft and known as the pit bottom. The place was illuminated by one or two badly smoking lamps. The smoke was stifling.

There is an old trick that is sometimes played even now on novices who go down for the first time. According to safety rules, the cage with passengers should be lowered at half the speed with which it takes down cargo. But not infrequently the cageman shoots it down at full speed, after innocently asking the passenger if he wants to take a ride "with a breeze." As it nears the bottom, the cage slows down abruptly and the man gets the feeling that

there is nothing under his feet and that he is falling into an abyss. This sensation lasts only a few seconds, for the body adjusts itself quickly to the new condition. It is a great relief for the passenger to see the pit bottom and miners scurrying to and fro!

I could not resist the temptation of getting the thrilling experience most persons get on their first descent into a pit.

From the pit bottom we proceeded with lighted lamps through a passage, called a lateral drift, to where the anthracite was being mined. The drifts, as well as the other underground galleries, looked much the same as in a modern mine, except that they were much lower and narrower. All the way we had to keep our heads low to avoid hitting the ceiling and that was rather tiresome. Sometimes I forgot about it and paid for it with a few good bumps.

My troubles were not over when we got to our destination; I had to squat and crawl through a small opening to get to the working face from which the anthracite was extracted and lugged to where it was loaded into tubs.

The seam was about 0.72 metre thick and bedded almost flatly, with a slant of only 6 to 8 degrees. Notchers, lying on their side along the drift about 3 or 3.5 metres apart, were chipping a narrow slot about 0.87 metre deep along the lower edge of the seam with an ordinary mattock. They tried to make the slot as narrow as possible so as to have less chippings. That was because coal slack was not marketable and was left in the mine as waste.

The team, consisting of notchers, hewers and tuggers, was paid at a fixed rate for each pood delivered in tubs to the surface. It should therefore be plain why the notchers tried to have less slack, which was neither counted nor paid for. During a shift, each notcher had to kerf his section of the working face. This job was called "a share." The excavated space or room contiguous to the coal wall, known as the stope, was propped with timbers at inter-

vals of 0.7 metre, the way it is done in modern mines. In those days a longwall (the working face of a drift stope) extended from 40 to 50 metres.

Crawling down the length of the stope, we emerged at the other end through another narrow opening in the upper lateral drift. It led to another stope from which anthracite was being hauled away. Here the seam was kerfed and then blasted with powder. Anthracite is very hard and compact and therefore hacking it by hand is unprofitable. I knew all that as a student, but I must admit that when I first saw it blasted, I was scared.

Anthracite fetched a higher price when it was in large lumps, so it was natural for the miners to try to get it out in the biggest hunks possible.

Slabs weighing from 35 to 40 kilogrammes were particularly valuable, for they were easier to unload, stack and store.

Coal was hauled out of the stopes on drag-sleds with wooden runners. Big hunks were loaded by hand and small ones, with fork-shovels. The small pieces which sifted through were relegated to the dump.

A drag-sled held from 120 to 160 kilogrammes of anthracite and was hauled by one man. Nowadays, when there are conveyors, it is easy to imagine how inhumanly hard was the job of the tugger, who harnessed himself to the loaded sled by running the sled-rope between his legs and attaching it to his belt.

Where seams were thin the tugger had to crawl on his hands and knees. On reaching the lateral drift he unloaded the coal at a place called "the station." If there happened to be an empty tub waiting, he helped to load the anthracite on to it. Ordinarily, the coal at the station was loaded by the tub-pusher himself, with a shovel or by hand. Loaded with half a ton or so of coal, the tub was pushed to the pit bottom, a distance of 500-700 metres, at most—1,000. But to push a tub with a load exceeding half a ton over such a distance was no easy job. At the pit bottom

the loaded tub was rolled into a cage and hoisted to the top, while another cage with an empty tub descended to the bottom.

After going through all the passages I realized how strenuously and with what primitive tools the miner had to work.

What made the job all the more unhealthy in those days was the pollution of air with suffocating blast gases, smoke and fumes. Even the miners admitted that hauling was the hardest underground job. The mine operators evidently had to reckon with that, I was told, and seldom extended the face of a stope beyond 50-60 metres because it was impossible to lug a sled over a longer stretch. Some stopes were longer, but in such cases there were more tuggers. This was unprofitable for the mine-owner because the tuggers were always in each other's way, their efficiency declined, and haulage became so expensive that it was cheaper to have two short stopes than a long one.

The anthracite pits I saw in the Sulin and Dolzhanskaya District were mostly owned by Russians. In the South, however, some of the mines were operated by foreigners, chiefly Frenchmen and Belgians. Labour conditions there were no better. Foreigners were not much interested in anthracite mines because they did not pay. In fact, productivity was so low that the entire output was consumed locally—by the Don Shipping Company and the big steam mills. Foreign companies sought concessions only where there were big coal and ore deposits.

Among the anthracite concerns there were only a few large ones, like the Wogau Company which operated pits near Krestnaya. Most of these pits were sunk to a depth of 50 to 150 metres. To illustrate what "mechanization" in those days meant, I will only mention the fact that the sole type of underground machine used in the mines in 1895 was a steam-pump for drainage. Things remained that way for many years.

When I returned to St. Petersburg I pondered long on what the future held in store for me and what a mining engineer like me could do to ease the toil of the miner. I had known before that the miner's work was very hard, but what I saw was far worse than I had imagined.

In recalling my early impressions of the Donbas I would like to mention one more thing that was typical of those times, even though it had nothing to do with mining. On the border between the former Yekaterinoslav Province and the Don Army Region was a mining settlement in which market was held several times a week. Among the vendors were some Jews. Under tsarist laws they were forbidden to live or even set foot in the "Cossack domain," though they could live in Yekaterinoslav Province. The border in question was the boundary of the "Jewish Pale," and the market-place was often the scene of ugly incidents. Here is one of the stories I heard:

A fierce-looking bewhiskered policeman approached a Jewish peddler who was standing by his cartload of goods and ordered him out because Jews were not allowed there. The peddler pleaded that although the cart was on Cossack soil, the horse was in Yekaterinoslav Province. The policeman conceded that the horse and even the front wheels of the cart were within Yekaterinoslav territory, but still told him to clear out immediately.

Such were some of the disgusting aspects of life in the old times.

In the summer of the following year (1896), I made my second trip to the Donbas and resumed work at Pastukhov's. This time I took a closer look at the coal mines. In the course of two months I had occasion to inspect some of the mines in the Alexandrovsk-Grushevsky (now Shakhti) anthracite area, where I collected material for my graduation thesis.

My assignment according to the Institute's programme for practical training was to get fully acquainted with two coal areas. The diploma thesis which I was to prepare

and uphold was to treat of the systems and methods of working flat seams in the Donbas, so I naturally took the assignment most seriously. I chose the Alexandrovsk-Grushevsky and Yuzovka (now Stalino-Makeyevka) districts because it was there that the largest coal mines were located.

In the Alexandrovsk-Grushevsky area I thoroughly studied operations in the oldest and largest of the mines, the one belonging to Koshkin. Later I saw the pits of the Shipping and Commerce Association. Two seams of anthracite, each 0.7 to 0.74 metre thick, were being worked in these mines. Bedded at an angle of 10 degrees, they were considered best so far as purity (sulphur and ash content) and hardness were concerned. The coal, in fact could be carted all the way to Taganrog and Rostov without breaking. The interesting thing was that the mine-owners preferred carting some of the large-lump anthracite to using branch lines of the South-Eastern Railway extending from the Shakhti Station. In early summer, usually after spring farm work was over, hundreds of ox-drawn carts converged on the mines from the surrounding hamlets and villages. The main advantage of cartage was that the Cossacks charged only three kopeks a pood. Moreover, coal was safer from breakage when carted, because delivery straight to the consumer eliminated extra handling.

The mines I visited in 1896 hardly differed from those I had seen near Sulin: stope faces of the same length, equally primitive methods of cutting, breaking and hauling, similar steam hoists for the tub-cages, and, above all, the same hard labour of the miners. The only thing new to me was horse-haulage. In the gangways, half-blind horses drew trains of six and eight tubs. I learned that horse-haulage had been introduced because the roadways in the old mines were growing increasingly longer as new seams were developed.

At the Koshkin Mine I saw the only surface pump-sta-

tion in the whole of Donbas. Powerful reciprocating rod-pumps, installed in a large building, pumped water from the bottom of the pit. Although it was a cumbersome installation the mine-owner had to use it because of the big inflow of underground water—more than 500 cubic metres an hour. I learned that the piston-pumps used at all the other mines were installed underground and not on the surface, and that later they were replaced with centrifugal pumps which required less room.

From the Alexandrovsk-Grushevsky anthracite area I moved to Yuzovka (now Stalino, the main city of the Donbas). At that time it was a settlement. The surrounding mines were mostly thin-seamed. The purest coal, used for the production of coke, was obtained from the Smolyaninov seam. The seams were of fiery coal emitting detonating gas. The safety rules then in force could never stand comparison with present-day safety standards in Soviet collieries.

Yuzovka was really more than a settlement; it was a small town. Besides the coal pits, it had the biggest metallurgical plant in South Russia. All these enterprises belonged to the British Hughes family who exploited workers mercilessly. They were sovereigns in their own domain, set their own rules and laws, and flouted even the provincial authorities.

Very few houses in Yuzovka were built specially for workers, and there were better houses for engineers and technicians. The rest were cottages owned by local tradesmen, and huts built by the workers themselves on rented plots. There was only one narrow, short street with city-type houses. At the end of this street was the market-place where peasants from neighbouring villages sold their produce. The street and the market-place were not paved and there were almost always clouds of dust in addition to the gas and smoke from factory chimneys. On hot summer days one could hardly breathe.

Such were my first impressions of Yuzovka.

I GRADUATE FROM THE MINING INSTITUTE

I began preparing for the finals as soon as I returned. Some ten years earlier, students had been given much more time to prepare and uphold their graduation theses. Lectures were discontinued three months before the end and the students did nothing but work on their theses. In 1897, when I was finishing the Institute, we were given no extra time for diploma work and had to do it chiefly during the intervals between lectures. We kept attending lectures on some of the special subjects, including mining mechanics, assaying and analytical chemistry. To do our diploma work, we had to forego some of our much-needed rest.

Our diploma theses did not deal only with subjects related to mining. In those years a graduate of the Mining Institute also qualified to work in the metallurgical and building industries, even though his professional degree was that of a mining engineer. The fact that the graduates were so diversely qualified is nothing to wonder at, for until the founding of the Mining Institute in Yekaterinoslav in 1899, the St. Petersburg Mining Institute was the only higher educational institution in Russia training specialists for both the mining and the metallurgical industry. Several years prior to my graduation there was a certain division between "miners" and "metallurgists." Future mining engineers were expected to concentrate less on subjects pertaining to metallurgy, and more on those relating to mining. In my time, however, such a division no longer existed and we had to study both mining and metallurgy with equal care.

A large room was set aside in the Institute for students working on their diploma theses and there we spent most of our time—from 9 a.m. to 11 p.m. After a few hours of hard study we would go to the student lunchroom or restaurant for a bite and then get back to our books. We

also had to attend lectures and laboratory experiments on assaying and analytical chemistry.

When I recall how hard it was for students in those times, I cannot help thinking of the really wonderful conditions in which our graduating students now work. At the Mining Institute where I now head one of the chairs, the whole faculty helps the graduating students in every possible way. Additional help from professors and instructors is a regular feature in all our institutions of higher learning. But when I was finishing the St. Petersburg Mining Institute, such help was a mere formality and a professor seldom gave advice to a graduating student. And when he did it was usually to tell the student where to look for the answers to his questions. He never bothered to test the graduating student's knowledge or help him to unravel the intricacies of a given subject. He hardly assumed any responsibility at all for the student's graduation work.

The examinations were marked by elaborate ceremonies and attended by eminent professors. The chairman of the State Examination Commission was V. I. Meller, the director of the Institute. Others on the Commission were two or three professors who conducted some of the fundamental courses, and a representative of the Ministry of Agriculture and State Properties, the patron of our Institute. Knowing that the Ministry had not pampered the Institute with its attention during the year, we wondered who the representative of the "higher spheres" would be. We were somewhat relieved to learn that the Ministry had appointed the well-known mining engineer A. A. Auerbach, who had once taught in our Institute. He owned the famous Nikitovka mercury mines in the Donbas and the Bogoslovsk coal mines in the Urals.

Auerbach was exacting but not captious. It was practically he who conducted the examinations and not Meller. He looked through all the diploma theses and, luckily, his appraisal seldom differed from the opinion

of our professors. His word counted most in deciding our fate.

I faced the stern Examination Commission with trepidation, for I had some serious points to uphold. For instance, on the subject "Metallurgy," I had designed an open-hearth furnace intended to fit conditions applicable to those at the Obukhov Plant, which at that time was one of the largest Russian steel mills.

My "building-art" project was a design of a two-storey house with four apartments, adorned with balconies and various architectural ornaments. My other diploma works dealt with no less important problems.

Moreover, there was eager competition among the students in presenting graduation works, because prizes had been set up for the best theses—the prizes for designs in mining mechanics being 100 and 50 rubles.

On the whole I did pretty well in presenting my thesis. I was awarded a first-class diploma and the degree of Mining Engineer. The class of the diploma was very important to the graduate since it determined his future career. A first-class diploma gave him the rather high civil rank of Collegiate Secretary, whereas a second-class diploma ranked him as a Gubernatorial Secretary, which was several rungs lower on the official ladder. The degree of Mining Engineer was conferred at a solemn ceremony on all the members of our class, and all were confirmed in that degree by the Minister of Agriculture and State Properties.

It might be worth mentioning in this connection that throughout the St. Petersburg Mining Institute's whole pre-revolutionary history of more than a hundred years there were only two instances, to my knowledge, when the Mining Engineer's degree was conferred not by the Ministry but by imperial decree. Both cases were characteristic of ethical standards in tsarist Russia.

For the first time the degree was conferred by the order of the tsar on Professor Timé's son—a not very bright

lad who had failed to win a diploma, all his father's efforts notwithstanding. Curiously enough, the Professor went so far as to curtail the higher mathematics course just to give his son a chance to cope with the lessons. This may sound anecdotic, but it is described in *The Reminiscences of a Metallurgist* by Academician M. A. Pavlov, a classmate of Professor Timé's son.

This "extraordinary measure" did not help and the lad flunked just the same. Nevertheless, he was granted the degree on imperial orders in reward for his father's meritorious service.

The second case of "august" intervention in the affairs of the Institute was even more anecdotic. The degree was conferred on a Persian prince, who had done his utmost to get the title, though nobody knew why he wanted it.

Long before my graduation, I began thinking of where to find employment a natural question that faced every graduate. I was fortunate in this matter. The last time I was in Sulin, Pastukhov had asked me to come back and work for him. The temptation to work in Pastukhov's far-flung mining and metallurgical enterprise, was too big for a young engineer and I did not hesitate for long. Apart from the three anthracite mines near Sulin, Pastukhov's possessions included more than a hundred small limonite mines, several pits for working underground deposits of limestone, and also some stone, and fire-clay quarries. These materials were needed in large quantities for industrial and housing construction.

N. P. Pastukhov was a very old man, and his business was run by his son and his brother—Sergei and Pyotr Pastukhov. The Sulin Works was managed by G. I. Kinkel, an able German-born engineer, who, I was told, disliked mining engineers, especially young ones, because he was afraid they might supplant him. His only real rival was M. K. Kozlov, the manager

of the Pastukhov mines, but he soon went to Rostov where he had his own enterprises. On my arrival in Sulin, Kozlov was still manager and I was appointed his assistant. That made me almost the "boss" of a large number of mines and quarries, and, naturally, I was flattered.

Besides coal, limonite and various building materials, I had to deal with timber, which came in abundance from Byelorussian forests and from Tsaritsyn (now Stalingrad) on the Volga.

The terms offered me were handsome, especially because as a student I had been accustomed to living on a scholarship—I was offered 150 rubles a month, plus an apartment. I also had a carriage at my disposal, for every day I had to cover about 40 kilometres. Since I had just married, I accepted the offer and went to Sulin. It was my first job as a mining engineer.

AT THE SULIN MINES

And so, when I came to Sulin in September 1897, it was not as a shy student but as a "big shot"—assistant manager of all the Pastukhov mines.

I worked for Pastukhov for more than three years—first as assistant manager and later as manager. I toured the area many times and got to know Sulin and the surrounding districts very well.

Together with Kozlov, I supervised the far-flung mines that supplied the Sulin Works with various raw materials. Kozlov was my chief for only a year, and after his departure the Pastukhovs put me in charge.

That period was distinguished by the rapid growth of Russia's coal industry. The importance of the Donbas as the country's main supplier of fuel was steadily increasing. At that time the Donbas included the Krivoi Rog iron-ore region, the Bakhmut salt mines and the Ni-

kopol manganese mines. Before relating what I saw in the mines, I would like to touch briefly on that period of the history of our country's main coal-producing area.

The Donbas began to develop intensely in the nineties. Coal output rose from 3 million tons in 1890 to 5 million in 1895, and to 11 million in 1900—a nearly fourfold increase in ten years.

It is noteworthy, too, that in 1900 the Urals coal fields yielded only 377,000 tons and those of the Moscow Basin, only 300,000 tons. In output of iron ore, South Russia also moved up to first place, outstripping the Urals, which had long been the leading producer.

The growing output of coal, iron ore and manganese was attended by the expansion of the metallurgical industry. The amount of pig iron produced from Krivoi Rog ore and with Donbas coke increased noticeably. In the ten years ending with 1900 it increased more than sevenfold—from 21,000 to 150,000 tons. The mills began to turn out a greater volume of high-grade and shaped iron, steel, ingots, wire, etc.

Most of the ore mines and metallurgical plants belonged to foreigners, who flocked to Russia in considerable numbers when they realized the immensity of our country's mineral resources. Taking advantage of the indifference with which the rulers of tsarist Russia regarded the mining of these resources, they began to exploit our mineral wealth. They bought up land at low prices, sunk mines, built factories, and, exploiting cheap labour, made huge profits, as was the case with the Novorossiisk Coal, Iron and Rail Company founded by the enterprising British industrialist, John Hughes. The history of that company sheds light on the ethics which then prevailed in the mining business.

A periodical of that time carried an article dealing with industrial development in Russia in general and with the southern metallurgical industry in particular. It stated impassively that the efforts of the tsarist govern-

ment to build steel mills in that area had all been unsuccessful and that "... it was only John Hughes, a man of exceptional enterprise and energy, who succeeded in laying a strong foundation for the development of Russia's southern metallurgical industry." Officials of the Mining Department spread a legend about the "amazing speed" with which Hughes had set up his enterprises in South Russia. The British industrialist, a former blacksmith, was pictured as "a democrat and self-made man." It was said that although he was "a stranger with no knowledge of the local language, customs or way of life, he had built up an industry in what was almost a wilderness."

Actually everything was much simpler. At a moderate price Hughes bought from the landowner Smolyaninov a small estate with lands abounding in valuable minerals. Peasants, eager to accept any terms just to earn a livelihood for their big families, flocked from all sides. Hughes was thus enabled quickly to build up his industrial plants with minimum expenditure.

Many other foreign capitalists joined in the ruthless exploitation of Russia's people and natural resources. The indifference of the tsarist bureaucrats to their country's fate was perhaps best evidenced by the fact that they gave away Russia's resources to foreigners for next to nothing.

New coal pits appeared in the Donbas almost every month. Mines were sunk alongside the Korsun pits of the South-Russian Mining Company (the present Kochegarka Mine, one of the biggest in the Donbas) and the numerous other old pits. Among the new enterprises commissioned in the nineties were the Yenakievka mines and a large mill, likewise owned by foreigners—the Russian-Belgian Company. In 1901-02 these mines daily produced about 1,600 tons of coal—quite an amount for those times.

The Yelpidifor (now Artyom) Colliery was one of the bigger mines in the Shakhti anthracite area; it belonged to Paramonov, a well-known Rostov merchant. One of the deepest mines in South Russia, it produced almost as much as the Yenakievka mines. Another new mine was the Novaya Smolyanka (now the Shvernik Colliery), owned by Hughes. Its depth exceeded 700 metres. It yielded excellent coking coal, known as the Smolyaninov grade. The Novaya Smolyanka was the main supplier of coke to the Hughes iron and steel works.

When I worked for Pastukhov, I had occasion to see a good many of the mines besides his. Near Yuzovka was Karpov's seven-seam Voznesensky Mine, sunk in 1881. Among the other mines I visited were the Berestovo-Bogodub pits, the Makeyevka mines (the most famous of which were Ivan and Sofia), and the Rykovo mines (where an underground explosion in 1908 cost 270 lives). Having seen all these mines, I formed a clear picture of the Donbas in the nineties.

THE OLD DONBAS MINES

The main aim foreign owners of the big collieries pursued was to get the most out of them, and to achieve this they resorted to mechanization, though on a very limited scale. Hughes introduced mechanical haulage and used pick hammers (of foreign make, of course) in the Yenakievka mines.

Such mechanization, however, was absolutely untypical of the old Donbas. Most of the mines I saw had very primitive equipment. In fact, their only "mechanism" was the muscle power of the miners, who hacked coal with picks and mattocks. That applied to the Pastukhov pits too.

The characteristic thing about the anthracite region was that the mines were small and belonged to Rus-

sians. The medium-size mines in the Dolzhanskaya area, north of the Pastukhov Ironworks, belonged to Rostov merchants and other Russian proprietors. The mines adjoining the British Coal Company in the Shakhti District were owned by the Russian Commercial and Shipping Company, and by coal-dealers Koshkin, Paramonov, and others.

The largest of the anthracite pits were in the neighbourhood of Shterovka and belonged to the industrialist Wogau. One of the biggest mines in the Donbas—the Karl Mine—was likewise situated there.

All these anthracite pits—I had come to know them very well—were considered small even in those times, when the workings were never deeper than 150 metres, and more often than not only 50 metres. Incidentally, it is wrong to think as some miners did, that the depth of a pit had any bearing on the nature of the underground structures. The only difference was in the length of the passages between the underground and surface workings and in the ventilation systems. The number of underground structures may have varied according to the output of the mine, but they were the same in both deep and shallow pits.

The coal mines predominating in the Donbas at that time were so interesting, judging by today's standards, that it is worth saying more about them than I have done in the chapter on my practical training.

The shaft top works was usually a level platform covered with cast-iron plates and fenced off on two sides with a wooden frame or, on rare occasions, with an iron one. Safety doors in both frames opened on the approach of the cage with a loaded or empty tub. The shaft collar usually had two sections, with one cage going down and another going up. Accordingly, one of the drums of the hoisting machine wound the ropes, while the other unwound them.

The cage came to a standstill with a slight jolt. At

a sign from the onsetter or foreman, the miner would walk out stooping into the almost complete darkness of the pit bottom where no lamps were used.

The pit bottom, usually propped with timber, was a rather large room about the height of a man, filled with smoky haze. From it ran the drift with a rail track, alongside which was a narrow foot-path for the miners and next to it, a drain ditch.

In most of the old mines, including the Pastukhov pits, the tubs were pushed by putters or, sometimes, drawn by horses. The more modern method of rope haulage was gradually introduced round about 1897-1900, but only in a very small number of mines.

In the main level it was also almost pitch-dark, the only light coming from the flickering "Godspeed" oil lamps. As I have said, the drifts were low and one had to stoop to walk through. The neck and the back ached and it was difficult to walk a long distance. In many mines the lateral drift was usually as much as 500 metres long, and sometimes longer. The miner followed the narrow foot-path between the track and the ditch to his place. To reach the coal face, he had to crawl through a small opening running perpendicular to the main horizontal drift slanting upwards. It was through this same opening that coal was brought out.

The notcher (who did the kerfing) and the hewer (who both kerfed and hacked) worked squatting or kneeling. They used picks or mattocks, sometimes thin crow-bars and hammers. The crow-bar was used more often in anthracite mines. With these simple tools the pitmen cut slots along the bottom of the seam. For decades the pick and mattock were used as the handiest tools; the advantage of the thin crow-bar, used like a chisel, was that it made a narrower slit. This meant fewer chippings and more lump coal. Since the pitmen were paid a fixed rate for each pood brought to the surface, they preferred using the crow-bar and hammer to raise their productivity.

The owners of the small anthracite pits tried to get as much coal as possible in big lumps, which brought them more than the smaller "nut" and "pea" grades.

Labour organization in those days (about sixty years ago) was rather peculiar. The mine manager would conclude a contract with the boss of a crew to work a coal face of definite length—from 30 to 50 metres, and pay him for every pood delivered to the surface. The crew boss paid the men on the same principle. And the latter figured out themselves how much each earned in accordance with "shares" or "tasks." To do a "task" was to cut a slot over 4 metres long. If the coal face of a stope was, say, 50 metres long, ten to fifteen hewers would work in a row at regular intervals.

The term "share" applied to the amount of coal obtained from a definite length of the coal wall.

The crew boss hired the workers, fixed their earnings and fed and housed them. The miners depended entirely on the boss and regarded him as more of an authority than the mine administration.

The single men lived in barracks, usually without ceiling or floor. Each barrack had two rows of bunks and a big square hearth covered with iron plates. Fuel was free, so it burned continuously. There was a nook for the housekeeper who did the cooking and was supposed to keep the barracks clean.

The crew boss managed the finances. He bought vodka for the miners on holidays and sometimes clothes. He told the housekeeper what provisions to purchase, as a rule in the store run by the mining company. Later he divided the expenses among the miners and it often happened that they had no wages coming and even owed him money.

The workers could buy food of better quality and at lower prices at the market, but usually they were penniless from one pay-day to another. Sometimes the boss made a deal with the mine operator to the latter's advantage. The mine-owner would agree to pay a small

extra amount for every pood of coal on the shackling condition that the food for the crew was bought only in his store. Such an agreement added to the privations suffered by the workers.

The wretched mining settlements—low huts and barracks perched on the slopes of gullies—were a miserable sight. Family huts were no better than the barracks. They were just as squalid, and without elementary conveniences.

The only more or less decent houses were those occupied by the engineers and technicians, but even they lacked plumbing. Water had to be brought in barrels. There were no gardens and the streets were unpaved. Still, compared with the family huts and the barracks, these houses looked like palaces.

In the pits, the seams were worked out in long faces; only pitching seams were worked in stepped faces. First the notchers kerfed a slot in the coal wall from 4 to 6 metres long and approximately one metre deep. When the slot was approved by the crew boss, the hewers got to work and broke off lumps of coal with wedges and heavy hammers. The tuggers, who worked alongside, hauled the lumps out of the stope.

There was little blasting done in the old mines because the wedge-and-hammer method, though far more toilsome, produced larger lumps and that meant more profit for the owner. Whenever a large amount of coal had to be got out at short notice and it did not necessarily have to be in big hunks, wedging gave way to blasting. The bore-holes were charged with powder and fired with safety fuses.

The miner's job was no easy one. The average "task" was 4 to 6 metres per person on a coal face extending from 30 to 50 metres. In those years the timbering was done not by timberers, but by the notchers and hewers themselves, though they were not paid for it. Nowadays, though we no longer have any notchers or hewers in our

mines, we still call the initial timbering "hewers' propping."

The notcher and the hewer usually worked together on the same team, especially when the coal was blasted. Their hard working day lasted for eleven and a half hours. The nocher looked for the bands of shaley matter called hussle or dirt, with which coal seams are interbedded in the lower, middle or upper parts, and which are easier to cut through because they are softer. It was easiest for the hewer to break down the coal when the seam was undercut down below, for then the weight of the hanging coal simplified matters.

What was labour productivity like in those days? If the section of a coal wall worked by the notcher was 4 metres long and one metre deep, he had to cut a slot of 4 square metres. The thickness of the seams in the Donets mines averaged about 0.7 metre. Consequently, miners' production per shift was between 120 and 170 poods. Later (at the turn of the century), the working day was shortened by one hour, that is, reduced to ten and a half hours. This shorter day, however, was ignored by many mine-owners.

Miners worked in two shifts. There were no preparation and repair shifts such as we now have in the collieries. As a matter of fact, with techniques then obtaining there was no need for them. After the hewers came the tuggers with their drag-sleds.

Whenever I think of the tugger's arduous labour, I recall "The Tugger," a short story by A. Svirsky. I read it many times and every time it brought back visions of the dismal pictures I saw sixty years ago. Speaking of the miners in the old anthracite pits, the author uses a terse but graphic definition—"free galley slaves."

"A strange four-legged animal emerged from the depths of the mine," he writes. "Chained to a flat box loaded with anthracite, it was crawling laboriously forward....

"The most astonishing thing was the forelegs of the queer animal: they were much shorter than the hind legs,

and the flat, round paws were much like those of a bear. The phenomenon was so striking that I was about to turn to my guide for an explanation, when the 'beast' suddenly stopped in front of us and raised its head. It was not an animal, but a man standing on all fours. His grey eyes were staring at me. The resounding clang of the iron chain as it hit the stone floor when he halted was followed by a dead silence.

"I could hear the man's quick breathing as he stood on his hands and knees. Dark-brown sweat streamed down his black face, which looked as if it had been smeared with boot polish. His whole body quivered from exhaustion.

" 'Who is that?' I asked my guide with a nod toward the grotesque man hitched to the coal box.

" 'A tugger. Just an ordinary worker.' "

Let me add that there is no exaggeration in this vivid description. I saw many such tuggers when I worked for Pastukhov. Our Soviet miners, especially those of the younger generation, who know only from books that there used to be an occupation called "tugger," will find it hard even to imagine how awful the labour of these underground workers was. Svirsky rightly called them "a galaxy of black galley slaves." The author mentioned that the tuggers wore boots with iron soles and their hands were protected only with leather mittens. To pull the heavy box of coal, the tugger had to strain every muscle. He was usually clad in rags that barely covered his body.

Svirsky relates that some of the tuggers looked like children, although they were 18 or 19 years of age. That is nothing to wonder at, for the darkness and lack of fresh air, coupled with back-breaking toil, retarded normal physical development.

Officially, child labour at that time was not allowed underground—a miner had to be at least 16 years old. But that was nothing more than a formality. Mine managers often hired boys who were only 13 or 14 but claimed

to be 16. The mining authorities overlooked this unlawful practice.

Children of such age were usually hired as assistant tuggers. They helped to load coal on to the drag-sleds—a very strenuous job because some of the lumps weighed as much as two or two and a half poods.

At the terminal of the trackway, near the passage leading to the stope, tuggers re-loaded the coal from their sleds into mine tubs. To make loading easier, a wide opening was cut in one of the sides of the tub. The opening was then blocked up with the biggest lump to prevent smaller coals from dropping out. In these tubs the coal was hauled to the pit bottom.

Different Donbas pits produced different anthracite. Miners attached no value to coal dust and chippings, leaving them in the pits as waste. But nowadays slack is used in large quantities as fuel for power plants.

I would like to dwell on the use of the slack which had accumulated in the old Grushevsky pits, where the seams had been almost completely exhausted. This slack remained there untouched for many decades. But when we set out to restore the Donbas shortly after the Civil War, and had gained experience in the use of coal dust in power plants, we turned the slack supplies in the Grushevsky pits to good account. There was so much of it that we had enough fuel for quite a long period.

The carrying capacity of the tubs in the old mines was not more than half a ton and they were pushed by a putter. More often than not he did not have to push the tub but just ran after it as it sped down a sloping gangway. The putter was paid a piece rate for every tub of coal delivered, so he naturally tried to keep the tub moving as fast as possible.

The roomy pit bottom, where sometimes quite a number of loaded tubs accumulated, had two rail tracks: one for loaded tubs and the other for empty ones. After bringing

in a loaded tub the putter crossed over to the other track and pushed an empty tub back to the loading place. It was often harder to run an empty tub than a loaded one, because it had to be pushed uphill.

The tubs of coal from the pit bottom were driven into a cage and raised one at a time. This is where "mechanized operations" came in, including electric hoists at the bigger mines in Yuzovka.

In most mines steam-pumps stood in a chamber adjoining the shaft. When they were in operation, the temperature in the pump-room and in the galleries close to the shaft often rose to 25-30°C. You can well imagine how difficult it was not only to work but even to breathe in such heat. No wonder the men near the shaft sweated so much although working stripped to the waist. Work in the pump-room and near the shaft was dreadfully oppressing.

In relating my visit to the mines in 1895, I mentioned that the old mines used both hand-haulage and horse-haulage. There were underground stables for the horses with stalls and troughs. All their short life—for they seldom lived more than eight or ten years, these horses remained underground without ever seeing daylight. There they were fed, there they grew old and often went blind, and there they died.

Miners worked in two shifts: day and night. The day-shifters hardly saw any daylight throughout the week they were on. They went down at six in the morning, and emerged at twilight, 10 or 11 hours later. It was only on Sundays that they enjoyed sunlight. The only "recreation" many had in their hard, humdrum life was vodka. There is nothing surprising about that when you come to think of the inhuman conditions in which they had to toil. They spent most of their earnings on vodka, leaving very little for their other needs.

More than once I witnessed painful family scenes near taverns where miners were spending the last kopeks of their pay on liquor while their wives tried to lead them

away and their children stood by and cried. The hard lot of the miners, by far the worst exploited proletarians of tsarist Russia, was vividly reflected in the songs sung by pitmen before the Revolution.

These folk songs expressed the people's thoughts and aspirations and told the story of their cheerless, despondent life. They were very popular in the Donbas. Today, the songs are studied as remarkable specimens of the pre-revolutionary folklore of the working people, as documentary evidence of the grim past.

The keynote of many of these songs was the miners' back-breaking work, in which there was "no cheer, only sorrow." "The Song of the Horse-Driver" recounts how the young worker, ignoring the brakeman's advice, leads the horse-train too fast and breaks his head. In "The Hewers' Song" it is said: "Death awaits us every day and keeps its door wide open." Other songs related how mines caved in, bereaving families of their bread-winners. The great vitality of the songs written at that time stemmed from the truthfulness and accuracy with which they depicted the miners' working conditions.

Day in and day out, from year to year, they toiled, relying only on their muscles, never dreaming that coal mining would some day be mechanized.

In their drive for maximum profits, foreign mine-owners sometimes tried to replace manual labour with machinery, but their efforts seldom succeeded. The imported machinery proved utterly unsuitable in Russian mines. Efficiency was quite often lower than that of manual labour and did not justify the expense. Many machines were put away after half a year, and the workers had again to shoulder the full burden. Even where there was a comparatively large number of mechanical mining devices, mechanization did not prove effective enough to justify its introduction, though in Germany, Britain and other countries it was quite widely applied.

The problem of mechanization was then approached

only from the viewpoint of financial advantage. Neither the mine operators nor the tsarist government cared anything about easing miners' exhaustive labour, or making their living conditions bearable.

In these circumstances it is only natural that the problem of mechanization remained unsolved for many years. The only concern of the engineers and technicians was to get the greatest possible amount of coal at the lowest possible cost, and no matter how much some of the progressive mining engineers may have wished to mechanize mining, they had no incentive at all to do so.

Looking back on the Donbas as it was at the close of the last century, I wish to emphasize again that its distinctive feature was the preponderance of small mines, whose number increased particularly after World War I broke out.

It is noteworthy that workers went to the small mines more readily than to the big ones. The reason was that contractors for the small mines employing 30-40 men frequently paid more than big mine operators—say, 35 rubles a month instead of 30. On a small payroll that difference did not amount to much. But in big collieries employing as many as 1,500 or 2,000 men, the fixed wage rate was strictly observed.

What were these small "mousetrap" mines like?

Labour conditions were no better, and often worse, than in the big mines. The average crew consisted of 10-15 men. It took them at least half a year to sink an inclined shaft. There was no need to build any structures. After exhausting one pit the men went to the next. Sometimes, when I rode along the crest of a slope where such pits were located, I would see miners at work with several horses amidst small heaps of low-grade coal.

Such were the outward sings of a "mousetrap" pit; those of a big mine were quite different. At that time and later, open coke-ovens were a frequent sight near a big colliery. When coking coal, they yielded valuable gases, which

burned brightly day and night. This was a typical sign by which a colliery could be recognized from afar.

The enormous rock dumps which one can now see at every colliery, were at that time a rarity. On the whole the coal mines were not so big compared to present-day standards, so it is natural that the amount of muck brought to the surface was not as great.

Those yielding 100-200 tons of coal per day or 300 at most, were classified as medium mines. There were a few bigger mines in the anthracite area, but most were "dwarf" pits with a daily output of 20 to 50 tons. Among the largest collieries were those operated by Paramonov, the Karl Mine at Shterovka, the Yusupova mines at Dolzhanskaya, and several others. Their daily output was naturally much greater.

In summing up my early impressions of the Donbas, I would like to point out that even though it accounted for approximately 87 per cent of all the coal produced in old Russia, it was basically a region of small mines, quite a few of which were extremely primitive. Some pits had not even a steam-engine or any kind of drainage system, and the miners and coal were hoisted by hand. Only some of the mines had artificial ventilation. The ventilators were operated by the same all-purpose steam-engine which did the hoisting. Most of the mines, however, were aired naturally, or, to be more exact, were not ventilated at all.

When I think of the small and medium mines operated by muscle power, horsepower and, partly, steam-power, I must say that the old coal basin could never stand comparison with the new, socialist Donbas of today. Since the advent of Soviet power, the Donbas has been reconstructed and re-equipped. As a matter of fact, it would be more correct to say that it has been completely rebuilt. The "mousetraps" and the incredibly hard, superhuman drudgery have gone never to return. When I occasionally visit the Donbas now, I think that everything I saw there many years ago was only a bad dream.

THREE YEARS WITH PASTUKHOV

It was during my three years with Pastukhov that I made all the observations recounted above. As a young engineer I had occasion personally to acquaint myself with the life and work of miners. Later, as a teacher at the Yekaterinoslav Mining Institute, I dwelt more than once on my early impressions in my talks with students.

About the time I arrived to take up my job, the Pastukhows purchased some old mines near Yuzovka from Ilovaiskaya, the bankrupt proprietress of the estate. Along with the mines they bought 162 acres of land, a big orchard, and the old manor-house. New coal pits were sunk on this land. In those days the development of mineral deposits depended on the whim of those who owned the land. That, of course, was detrimental to mining and metallurgy. It was not infrequent that landowners, in most cases short-sighted people with very little concern for Russia's interests, did not allow prospecting on their land. Long-drawn-out suits often ended in favour of the landholders because the basic principle of the capitalist system, which regards private ownership as sacred and inviolable, was very rigidly observed. That was why mine operators sought to buy up as much land as they could, even if it had never been prospected.

While I worked for Pastukhov, he enlarged his enterprise by adding some small coal pits and quarries.

The workers he employed lived a cheerless, wretched life. Despite the fact that Pastukhov was regarded as progressive and liberal among the industrialists of South Russia, his miners fared no better than their colleagues elsewhere. I often had to visit the mines in my charge, some of them quite far away from Sulin, and everywhere I saw pictures of agonizing labour and a miserable, almost beggarly existence. Miners and smelters were paid better than other workers. Nevertheless, they were barely able to make both ends meet.

Regulations obliged our miners to buy food only at the stores run by Pastukhov. Later the government prohibited industrialists from running stores which sold food on credit. This did not make things any better for the workers. The only difference was that formerly they had been able to buy things on credit and settle accounts on payday; now they had to pay cash and this most of the time they did not have. So it is hard to say what was worse.

I have mentioned above that vodka-drinking was about the only "recreation" pitmen had, for in those days there were no cultural activities or facilities in mining settlements. Seeing how cheerless life was, I tried to do something for the miners. I was very young and rather naïve then. I thought I could better the life of my subordinates.

In Sulin, several other young engineers and I helped to organize "popular readings," accompanied by "magic-lantern" shows. These readings familiarized the workers with Lev Tolstoi, Korolenko, and other writers.

It goes without saying that the books read were only those passed by tsarist censors, and then only those "allowed in public libraries."

The readings gathered big audiences. But of course they had very little effect on the life of the workers. In our well-intentioned zeal to teach people what was "wise, good and eternal" we had overrated the importance of this measure. Nevertheless, the readings undoubtedly broadened the miners' horizons.

There was a vacant warehouse near the ironworks and we got the management's permission to use it, turning it into a small theatre by building a stage and installing a hundred seats. In the plays we staged, some of the performers were workers, but most were office employees and members of their families. The plays, usually one-acters with very simple plots, were staged once a month, sometimes once in two months. I recollect that one of the plays was called *Trust a Lady To Have Her Way*. It was one of the

most popular of the vaudevilles shown then, with dancing and music.

Neither Pastukhov nor the watchful police objected to these amateur performances, for they realized that inoffensive entertainment like this diverted people's thoughts from the causes of their misery.

The reaction of the local authorities to the rumour that the popular readings were being used for other purposes was entirely different. The fact was that some of the forward-looking young factory workers realized how much those harmless gatherings could benefit the labour cause. At the readings and at our rehearsals, young people began to evince interest in political self-education. They read illegal Social-Democratic leaflets brought from Rostov and urging resolute revolutionary action against autocracy. Illegal Marxist pamphlets were likewise circulated. I remember one of them was entitled *Tsar Hunger*. It was very popular among workers because it denounced the exploiters. I learned afterwards that it was written by A. N. Bach, later a prominent chemist and member of the Academy of Sciences.

This sort of pastime, which could hardly be called harmless, soon attracted the attention of the plain-clothes. The popular readings lasted for four months only. Then a gendarme arrived from Novocherkassk and ordered them suspended. He told Pastukhov that the magic-lantern shows were implanting undesirable ideas. Frightened, Pastukhov promptly obeyed the order. The incident was significant, I would say, for two reasons: it showed what one had to cope with in tsarist Russia to enlighten the workers, and it showed that the Social-Democrats took advantage of every opportunity to conduct revolutionary propaganda.

Engineers working for Pastukhov enjoyed many privileges, and our life radically differed from the inhuman existence of the workers. I tried my best to improve their condition, but my efforts were only a drop in the bucket

and, furthermore, were thwarted by the conservatism of my employer. Although I was the manager of the mines, I could do nothing effective to alleviate the lot of the workers without Pastukhov's knowledge and consent. And he thought least of all of the miners' welfare even though, as I have already said, he had the reputation of a liberal man.

I planned my work in my own way and visited the mines when I saw fit. So in that respect I was more or less independent.

Financially, I was pretty well off. The Pastukhovs treated me well and usually gave me a month's salary as a bonus at the end of the year. My relations with other engineers in Sulin were also good, especially with M. A. Pavlov, a young metallurgical engineer, who, like myself, had graduated from the St. Petersburg Mining Institute

Although my position might have been envied by many other young mining engineers, the thought of taking another job persisted after two years. I found it difficult to see the miners' miserable working and living conditions every day and every hour without being able to do anything about it.

I felt that the only way out was to leave Sulin. But where was I to find another job? An engineer as young as I was could hardly expect to be offered such excellent terms elsewhere, but that was not the only consideration. The main point was that working and living conditions were equally abominable at all mines.

I was delighted to read in the papers that a mining institute—the second in Russia—was about to be founded in Yekaterinoslav. The first was the St. Petersburg Mining Institute. Early in 1899 the newly-established institute advertised for teachers.

The new institute, it was announced, would offer training in two special branches—mining and metallurgical engineering applicable to conditions in South Russia. Thus the curriculum was to be like that at the St. Petersburg Mining Institute.

This report aroused interest among all young engineers. What appealed to them most was that this would not be just another secondary mining school for foremen and technicians, of which there already were many in Russia, but a higher educational institution for training engineers.

I soon learned that the name of the director was S. N. Suchkov, an engineer from Kharkov, who was said to be a decent and kind-hearted person.

I decided to try my luck and get a teacher's job at the Institute. Pavlov also wanted to teach there. He was with Pastukhov much longer than I, and often told me that he was anxious to leave. Pavlov soon left for Yekaterinoslav to see Suchkov.

I waited impatiently for his return. He called on me the moment he returned, and described his trip. The result was most favourable. Suchkov received him very well, Pavlov said, and was pleased to hear that he wanted to join the faculty, for he had been trying to find a suitable person to lecture on iron and pig iron. Pavlov agreed to teach both subjects, but on one condition: he would start not at the end of 1900, as Suchkov wanted him to, but in January 1901, after the commissioning of the new blast-furnace at the Sulin Plant, whose building he was supervising. The Yekaterinoslav Institute, he told me, was short of teachers in other subjects too, particularly in mining.

That decided me to try to join the faculty. Soon I had to go to Yekaterinoslav on business, and I called on Suchkov and offered him my services.

Suchkov received me very cordially. Our conversation was much in the same vein as his talk with Pavlov. Evidently assuming that the matter was settled, Suchkov said:

"Well, I'm glad you're joining us. The main advantage of your new job will be almost three months of complete freedom every year. Tell me, have you had a vacation while working for Pastukhov?"

I had to admit that I had not.

Although my salary as a teacher would be much smaller, I readily accepted the terms. Suchkov assured me that the small salary would be temporary and that subsequently I could be promoted from visiting professor (the capacity in which I was engaged) to staff professor.

The matter, that is, my transfer to the Institute, was facilitated by Professor D. N. Katsovsky of the St. Petersburg Mining Institute, who recommended me.

On my return to Sulin, I tendered my resignation to Pastukhov. He did not want to let me go and offered me 700 rubles a month—the highest an engineer received—if I would remain. But I stuck to my decision to move to Yekaterinoslav.

In September 1900, six months ahead of Pavlov, I left for Yekaterinoslav with my family and the few things I had, for all the furniture belonged to the company. That was the beginning of a new phase in my life—of my 22-year teaching career at the Yekaterinoslav Mining Institute.

I was given a cordial send-off by my colleagues and the miners. For more than half a century now I have been keeping the address presented to me by the workers at my departure. I would like to wind up the story of my first job as a mining engineer with a couple of lines from the address. But let there be no mistake: I am not quoting these lines to show what a good chief I was and how much I was appreciated, but to emphasize how grateful the workers, who were savagely exploited, were to anyone who treated them fairly.

In their address they said: "To us, you were an equal member of our mining community... a man who brought light into our dull, murky life."

I have had occasion to hear many pleasant words in the course of my long life in the mining industry. But it is those few lines of the Pastukhov miners that I cherish as the greatest appreciation of my activities. And now, as I look back to the early period of my life and sum up what I have done, I cannot help recalling the plain, hearty words of that address.

THE YEKATERINOSLAV MINING INSTITUTE

The foundation of the Yekaterinoslav Institute* further tipped Russia's general industrial balance in favour of the mining and steel industry in the South.

It was not accidental that Yekaterinoslav was chosen as the location of the new institute. By the end of the nineteenth century Yekaterinoslav had become one of the country's biggest industrial and in certain respects cultural centres. As I have said, the mining and manufacturing industries developed at a fast rate in South Russia during that period. The last decade of the past century was particularly illustrative.

The increasing mineral output stimulated the expansion of the metallurgical and other industries, and the rapid growth of the fuel and steel industries was the main reason for establishing a second mining institute.

If you were to look at the map of South Russia, you would see at a glance that Yekaterinoslav is the actual centre of a far-flung industrial area abounding in raw materials. To the east is the Donbas. Near by are the Bakhmut salt beds and deposits of other valuable minerals: mercury, limestone, dolomite, fire-clays, etc. To the west are the Krivoi Rog deposits of iron ore and of secondary but indispensable minerals—brown coal, shale, graphite, mineral pigments and various building materials. Southwest of Yekaterinoslav is the famous Nikopol manganese area, which even then was of world importance. Not far from the city are the Caucasian oil fields, the mineral-rich Crimean Peninsula and the salt deposits along the shores of the Black and Asov seas.

Moreover, Yekaterinoslav was connected with the mineral deposits by a ramified network of roads. The city itself was on a railway line linking the Donbas coal fields with

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* Yekaterinoslav has since been renamed Dnepropetrovsk, and the Institute is now known as the Artyom Mining Institute.

the iron deposits of Krivoi Rog. All around the city were smelting and metal-working plants of considerable size.

I was well familiar with the story of how the Yekaterinoslav Institute was founded, and it so clearly exposes the disgusting attitude of the tsarist government and officials towards their own country's mining business that I think it is worth dwelling on some of the details. The rapid expansion of the iron and steel industry in South Russia required more specialists in mining and metallurgy. That being the case, we all expected the tsarist administration to wake up and take steps to set up another mining institute. But that did not happen.

The initiative came from the public, which insisted on setting up a new mining institute. The need for this was emphasized in newspaper articles, which began to appear in increasing numbers since early 1896 not only in Yekaterinoslav, but in Kharkov and even in the capitals. In that year the Yekaterinoslav Municipality asked permission to open a mining institute. Let me repeat that it was the Municipality, not the Mining Department.

The Iron-Makers' Advisory Board likewise appealed to the Ministry of Agriculture and State Properties, which exercised authority over the mining industry, and to the Ministry of Public Education, stressing the necessity of another institute. The Board was well familiar with the "generosity" of government agencies, and its only request, therefore, was to open a mining faculty at the existing Polytechnic Institute in Kharkov or at least to set up a secondary "mine-foremen's school" in Yekaterinoslav with metallurgical and engineering faculties. The Congress of Mine Operators of South Russia, held at about the same time, acted more boldly. It went beyond the mine-foremen's school idea and asked for an institution that would prepare mining specialists, suggesting that it be established in Yekaterinoslav. This petition was upheld by the Zemstvo of Yekaterinoslav Province.

Thus, the only voice heard so far was that of public

organizations. But it grew so loud and persistent that the government could no longer remain silent. As stated in one of the accounts of the Institute's history, "this important question was then referred to the appropriate ministries in the capital." That is when the usual departmental red tape began. In the following year the Minister of Agriculture and State Properties called an inter-departmental meeting, which was attended by representatives of the Mining Department and the iron manufacturers. After that, the issue was taken up by a special commission organized by the Mining Department. It took the commission two long years to settle a question that was clear to every sensible person. It was only towards the end of 1898 that the statutes of the Yekaterinoslav Mining Institute, the curricula and the staff arrangements, drafted by the commission, were forwarded to the State Council. It seemed as if the institute were about to be opened at last, but it was not decided by the government until the following summer. The most interesting part of the story began after the government appeared to have solved that "very intricate" problem.

The government obviously should have simultaneously decided on the allocation of funds for the building of the institute. But it did not. The tsarist authorities never bothered about the promotion of new educational institutions. The building had to be erected with public donations. The main benefactors, whose contributions made the opening of the institute possible, were the Mine Operators' Council of South Russia, the Zemstvo of Yekaterinoslav Province, the Municipality and the big mine- and mill-owners.

By mid-1899 contributions approximated half a million rubles, but not a kopek of it came from the Mining Department.

I missed the opening ceremony because I arrived only for the beginning of the second-year term, but I knew all about it from the papers and from the accounts of those present.

The Yekaterinoslav Mining Institute came into existence on October 12, 1899. It was quartered temporarily in what

was known as the Potyomkin Palace because the city authorities were unable to find suitable premises. The Institute's own building was completed two years later.

The inertness and sluggishness of the governmental departments in charge of education was clearly manifested when the nature of the new educational institution had to be determined. Since the mining and metallurgical industries were making rapid headway, especially in the South, it was obvious that the type of school needed was a second mining institute like the one in St. Petersburg. This was obvious to everyone except the higher spheres. Although the government had intended to open a higher educational institution in Yekaterinoslav, it only went half-way. It must have felt uneasy about opening just another secondary school, yet it feared that an institute might entail too big an expense. So it made a queer compromise.

During the first few years of its existence, the Yekaterinoslav Mining Institute was in fact a semi-higher educational institution. On the one hand, it was open only to those graduated by secondary schools, like every real institute; on the other, it conferred on graduates not the professional degree of an engineer, but only that of a technician. So it was really a hybrid, something between an institution of higher learning and a secondary technical school. This abnormal condition could not but affect the system of instruction and the graduates' qualifications. The history of the Institute's first decade was essentially the history of its fight for the legitimate rights of a full-fledged institute.

Four years after it was founded (in 1904), the Institute's three-year course of instruction was extended to four years, and, more important still, it was at last decided to graduate engineers and not technicians. In the following year the young engineers were granted licence to supervise construction work. But it was only in 1912, when the Institute was 13 years old, that it was finally reorganized into a full-fledged Mining Institute. So actually it was only five

years before the Great October Socialist Revolution that Russia got her second higher educational institution for training mining specialists.

When I began to teach there, the Yekaterinoslav Institute had two faculties: mining and metallurgical. This system lasted until the Great October Revolution. The question of broadening its scope came up shortly after the Revolution, and in 1919 two more faculties were added: geological prospecting and mine surveying. Another two faculties—mechanical and electrical engineering—were established in 1921 by reorganizing the Yekaterinoslav Polytechnic Institute.

When it opened in 1899, the Institute had an enrolment of 77. At the time this class graduated in June 1903, the number of students was 118. Most of them—89—were in the mining faculty and the rest, in the metallurgical one.

The original curricula drawn up by the Mining Department had certain drawbacks. They lacked the elements of co-ordination and sequence which are essential in terms of methodology, and ignored the main principle of pedagogics—the exposition of subjects by transition from the elementary to the complex.

In the second school-year, the serious flaws in the curricula became so obvious that the Institute's Council decided to revise them.

Although much time was given to practical studies, they treated only of general and analytical chemistry, physics and mineralogy, but did not touch upon two fundamental subjects—mining mechanics and mining. Later, when a mechanical laboratory was set up at the Institute, the students began to acquire practical knowledge of gas and steam-engines.

Practical experience, even though limited in scope, did the students a great deal of good. For students passing to the second-year course, there were summer excursions to factories and mines lasting from 10 to 15 days. The students of both faculties also had to go through a month of

practical training in geodetic survey. When passing to the third-year course, students of the mining faculty went through a month of practical experience in mines, and those of the metallurgical faculty were obliged to take two months of professional training in factories. Between the third- and fourth-year courses the students spent from 15 to 20 days on geological excursions and had a 45-day practice in mines and factories, during which they gathered data for their diploma theses. Now, after many years, I can note with satisfaction that the training received by students at the Yekaterinoslav Mining Institute was of high quality, and that explains why young engineers were so well received in the mills and mines of South Russia. Incidentally, the St. Petersburg Mining Institute, seeing how practical experience improved training, also made it obligatory for the students to engage in practical studies during the summer. When I studied in St. Petersburg, such practical experience was not compulsory and was not controlled.

And so, I moved to Yekaterinoslav in September 1900.

Compared with Sulin, to which I had become accustomed, Yekaterinoslav was a big and lively city. There was a number of large and small metallurgical and metalworking plants around it, and a few rather big factories in the city itself. In every other respect Yekaterinoslav was a typical provincial capital of old Russia.

The first difficulty I encountered was finding a suitable apartment. The apartment I rented was quite expensive and far from the Institute. It took approximately a third of my salary which, at first, was only 2,000 rubles a year. My salary was raised to 3,000 rubles when I became a staff professor several years later.

I noticed from the very start, even before the studies began, that the teachers were divided into two antagonistic "camps." The smaller comprised the professors who were members of the Institute's Council. In the second camp were the rest, and they, of course, were in the majority.

The Council itself, however, was not homogeneous and was split into two groups. The more conservative group, consisting of seven men, was headed by I. V. Kurilov, a professor of chemistry. The other group—a liberal one—was headed by L. A. Yachevsky, a professor of mineralogy and geodesy. There were only three members of the Council in the second group and they were always in the minority, but they did give the others a hot time during stormy arguments on various aspects of education.

In general, some of the professors looked down on their associates who, like myself, had worked in factories and mines. Until we presented our theses, several other young teachers and I were "acting professors" and were, at best, treated condescendingly by the "real" professors.

I once happened to hear a conversation which was quite characteristic of the tone adopted towards practical engineers by persons who considered themselves true scholars. A professor of that type expressed indignation over the fact that an unknown engineer from some second-rate factory in the Urals had been appointed professor in such a reputable educational institution as the Yekaterinoslav Mining Institute. His words could apply only to my old friend Pavlov, the only teacher in our Institute with a long record of practical work in the steel mills in the Urals. It would seem that that was not a drawback but a praiseworthy quality in a young educator, but my learned colleague thought otherwise.

When I related the conversation to Pavlov, he decided to have a talk with the professor. Nothing came of it, he told me later, though he had applied a good deal of eloquence trying to persuade the venerable professor to change his attitude towards educators with practical background. Pavlov told the professor about his 15 years of factory experience, which added greatly to his practical knowledge in metallurgy. For politeness' sake the stubborn adherent of "pure theory" pretended to agree with Pavlov; in actual fact, he stuck to his own opinion. Insignificant

though it seemed, this incident was typical of the widespread attitude towards young practical-minded educators prevailing then not only in educational institutions, but among the top officials of the Mining Department as well.

Fortunately, not all of our teachers shared this attitude. In the Yekaterinoslav Institute the students, as I have already said, were given practical training and therefore the overwhelming majority of the teachers attached much importance to the practical experience acquired in factories and mines. Needless to say that such experience enriched the theoretical courses and made them more interesting and valuable for the students. On the faculty at that time there was a whole galaxy of distinguished professors and teachers, many of whom made outstanding contributions to both Russian and world science.

Professor I. K. Sobolevsky, for instance, whose subject was mine surveying and geodesy, founded a new branch of science known as "underground geometry," which greatly facilitated the exploration of Russia's mineral wealth. The works of this eminent scientist were continued by Professor P. M. Leontovsky, who taught at the Institute from 1904 to 1921. Later, the theoretical principles evolved by Sobolevsky and Leontovsky were brilliantly developed by I. M. Bakhurin, a corresponding member of the U.S.S.R. Academy of Sciences, and his pupils.

Many important problems pertaining to the geology and palaeontology of the Donbas were solved by the prominent geologist N. I. Lebedev, who taught at the Institute for almost 30 years from 1900 (the year I joined it).

The course in mineralogy was first conducted by Professor L. A. Yachevsky and later by Professor L. L. Ivanov, who won renown by his study of minerals in the Ukraine. He joined the Institute in 1908 and his fruitful work there as an instructor and scientist continued for almost 40 years.

Sound theoretical and practical knowledge of mining mechanics is of vast importance to students. From 1906 this course was conducted by the famed Russian scientist M. M. Fyodorov, who subsequently became a member of the Ukrainian Academy of Sciences. He did a lot of valuable research in different fields of mining mechanics, and especially in mine-hoisting dynamics. His fundamental work *Theory and Calculation of Harmonic Hoisting* was well known to miners before the Revolution. In it he expounded his valuable theoretical calculations on hoisting shaft dynamics. Also important was his elaboration of the theoretical principles of harmonic hoisting with full dynamic equilibration of the mechanical system.

In general, the Yekaterinoslav Institute had a splendid staff of instructors in applied sciences. The teacher of structural mechanics from 1906 to 1929 was Professor S. A. Zaborovsky, a distinguished expert whose research in 1910 produced the useful theory of dynamic calculation of double-deck shaft cages. This theory contributed to safer and more economical labour conditions in the mines.

Another eminent professor who later taught this subject was Academician A. N. Dinnik.

A leading mathematician was G. A. Tikhov, now a corresponding member of the U.S.S.R. Academy of Sciences and one of the best-known Soviet astronomers. Lectures on applied mechanics were delivered by Professor Y. I. Grdina, a man of great talent. His scientific works enriched many of the important and most intricate divisions of theoretical mechanics and physics.

The lectures on metallurgy were very interesting and useful. Academician M. A. Pavlov, veteran Soviet metallurgist, who began his long teaching career in Yekaterinoslav, was our first teacher of this subject.

Among the prominent scientists who lectured on this subject later on were P. G. Rubin, A. P. Vinogradov, L. M. Fortunato and A. N. Pokhvisnev. Students eagerly attended the lectures of V. M. Makovsky, who later became

Honoured Professor of the Ukrainian Soviet Socialist Republic.

The teachers of mining were no less distinguished. The early years of this century were marked by an absolutely new trend in the exploration and development of our country's mineral resources. This trend was gradually to develop the *art* of mining, which was mainly an applied art put to narrow practical use, into a real mining *science.*

There had been efforts to create a course in mining that would combine practical experience with profound theoretical knowledge. One example was the text-book on mining written by I. A. Uzatis, a well-known mining engineer in the first half of the nineteenth century. His book was of considerable practical and theoretical value, but by the time I began to teach it had become a rarity obtainable only through second-hand booksellers.

The basic manual for students of mining was Doroshenko's, published in 1880, but its value was practical rather than theoretical. It contained instructions and information relating to particular mining operations, as well as descriptions of various techniques borrowed from abroad. Such a book obviously could not give the students an adequate theoretical background.

Another book was by Professor Romanovsky, but it treated only of certain aspects of mining and was very incomplete. Instead of familiarizing the student with the theory of mining, it contained only instructions.

The important theoretical and practical data were sufficient for a substantial course in mining. It could be justly claimed, in fact, that mining was a real science with a sound theoretical foundation and that it did not depend entirely on the skill and competence of veteran workers.

The important task of transforming mining into a science was greatly facilitated by the works of outstanding researchers and educators on the staff of the Yekaterinoslav Institute.

Credit is due to Professor M. M. Protodyakonov, who joined the faculty in 1904, for working out the theoretical principles of the exploitation of deposits. His most noteworthy achievement was research into the problem of underground pressure and mine timbering.

Roof-control and bracing are the main problems of mining, whose effectiveness depends on their proper solution. Professor Protodyakonov founded a school for the study of rock pressure and completed a programme of research into the bearing of underground pressure on mine timbering. Later this work won him his doctor's degree.

Mathematical investigation into underground pressure control was carried out by Academician Dinnik and his pupils.

The first decade of this century marked the beginning of the analytical trend in mining, which became an important division of the mining science. This trend appeared in the works of Academician L. D. Shevyakov, a professor at the Yekaterinoslav Institute for a number of years and renowned as a mining researcher. For a long time Shevyakov worked on important problems concerned with the stripping and developing of coal beds and with determining the dimensions of coal fields. He further developed the theoretical principles of winning coal beds, worked out earlier by Professor B. I. Boky of the St. Petersburg Mining Institute.

The scientific works of Protodyakonov and Shevyakov not only enriched the art of mining, but, more important still, contributed to the rise of a truly progressive mining science.

The merit of these eminent Russian scientists was that in their endeavour to lay the foundation of Russian mining science they followed their own path. The instruction course they conducted was based both on their theoretical works and on Russian mining experience. That was a big achievement, for in those days the books used by the students and teachers were chiefly by French, Belgian and

German authors, such as Haton de la Goupillière, Demanet and Emil Treptow. I remember using those textbooks myself, and I am sure that a good many of our veteran mining engineers who had studied at that time at the St. Petersburg and Yekaterinoslav institutes, also remember the Russian edition of the Demanet manual, then the most popular book on mining.

Perhaps these books were not bad by the standards of the time, but the examples cited were taken from French, German and Belgian experience, and the teachers had to supplement the books with examples from Russian experience.

The scientists and instructors mentioned above, the author included, faced the very difficult and important task of compiling a complete Russian mining manual combining theoretical knowledge with examples from our own country's experience in mining and metallurgy. There were plenty of facts to go by, but they had to be sifted and systematized.

At the end of 1901, I published a manual called *Underground Transport*. And while it fell short of a theoretically grounded scientific text-book of mining, it did, to some extent, fill the gap in one of the important divisions of mining. I had planned to write a book covering the whole course in mining, and this manual was to be part of it. The title of another manual which appeared in the same year was *The Mining of Minerals*. I was satisfied with my accomplishments, very modest though they were. As a matter of fact, the 1901 edition of *The Mining of Minerals* had nothing about such important items as mine ventilation and lighting.

They were dealt with in the edition which appeared two years later—in 1903. *Structures and Equipment in South Russian Coal Mines*, published in the same year, was another part of the general course of mining to which I devoted several years. The chapter "Mine Timber-

ing" was written in 1905 and "Mine Fires and How To Fight Them," in 1907.

I tried to embody in this work the experience I had accumulated while working for Pastukhov, as well as that of the mining industry in South Russia. That required much effort not only because there were not enough reference books to go by, but also because I had to make a large number of complex drawings. Assembling and systematizing the great volume of theoretical and practical data took considerable time.

I used all that as a draft for my thesis for the degree of Adjunct of Science, which I later upheld at the St. Petersburg Mining Institute.

The opening of the Yekaterinoslav Institute was one stage of the drive for the reorganization of mining education. Compelled to reckon with the growing requirements of the mining and metallurgical industries, the tsarist government devoted more attention to the training of mining experts. As in the case of the Yekaterinoslav Institute, the initiative came from public organizations, but the fact that the "higher spheres" had to attend to the matter, was, in itself, very significant.

A technological institute was opened in 1900 in Tomsk, the oldest industrial and cultural centre of Siberia. This was due among other things to the building of the Great Siberian Railway which opened vast prospects for Siberia's industrial development. The Tomsk Technological Institute had two faculties when it opened—engineering and chemical; a mining faculty was added a year later. Its establishment was a result of the swift expansion of the mining and metallurgical industries in Russia's north-east.

The Don Polytechnic Institute, founded in Novocherkassk in 1907, also had a mining faculty, its object being the training of engineers for the coal, ore and oil industries in south-east Russia and the Caucasus.

The establishment of a mining engineering college in

the Urals had by that time become an urgent issue. The Urals metallurgical industry had a long and glorious record, and although the owners of the mines and mills clung to the "sacred" traditions of their forefathers, they realized perfectly well that a mining school in that part of the country was absolutely necessary. The question of opening a mining institute in Yekaterinburg (now Sverdlovsk) was debated in the capital for several years, but it was only in 1916 that it came into existence.

So, Russia had only a few higher mining institutions prior to the Great October Socialist Revolution. Besides the St. Petersburg and Yekaterinoslav mining institutes, there were the mining faculties of the Tomsk Technological Institute and the Don Polytechnic Institute. If you add the Yekaterinburg Mining Institute, set up a short time before and still in the stage of organization, plus the mining faculty of the Warsaw Polytechnic School, you will have all of the higher mining schools set up under the tsarist regime over a period of several decades. It goes without saying that the small number of these institutions could not meet the growing requirements of the country's mining industry. The total enrolment hardly exceeded 2,000, with only 60 to 70 mining engineers graduating each year, which was far below the number needed.

Little wonder, then, that there was a big shortage of engineers in all of Russia's mining regions. Even such big mines of the Donbas as the Elpidifor or the No. 1 in the Gorlovka District (now Artyom and Kochegarka) had only one or two engineers. Mines of such size, with their various surface plants and facilities, normally required at least between eight and ten engineers if they were to be properly managed and technically supervised, so you can picture how hard it was to get along with only one or two. Due to inadequate technical inspection breakdowns and accidents were frequent, and coal mining operations could not be modernized.

If you also consider the fact that many of the engineers never went down into the mines, but had office jobs as administrators, directors or company agents, you will understand more readily the urgent need for competent engineers and technicians. Unfortunately, that did not worry the Mining Department. Forward-looking engineers, seriously concerned with the development of their country's mining industry, did everything to improve the situation, but their efforts were foiled by the passivity and conservatism of the tsarist administration.

Progressive-minded and honest instructors of the few existing mining colleges did their utmost to give the students a better training and imbue them with a real devotion to their profession. It was with real pleasure that I later saw many of the graduates of the Yekaterinoslav Mining Institute become members of the comparatively small but well-knit army of Russian mining engineers, who were vitally interested in advancing Russia's mining and metallurgical industries.

I began my teaching career at the Yekaterinoslav Institute in high spirits. Our students were fine lads and they eagerly grasped at every sincere word spoken about their country and its resources. It took a long time, however, for the studies to be set right, and that, I think, was the only instance when the upright and truly progressive professors and teachers were glad to see established regulations transgressed. These transgressions were due to the revolutionary ferment which had begun in the country shortly after the Institute was opened. Our students took part in some of the important events and that stimulated the growth of their political consciousness. I mean the widespread student disturbances of 1900-08. Although they occurred more than half a century ago, I distinctly remember those stirring events.

STUDENT DISTURBANCES IN YEKATERINOSLAV

The closing years of the last century and the early years of this were restless in Russian college life.

Rumours reaching Sulin, where I worked at the time, spoke of large-scale student disturbances in St. Petersburg. Despite the rigid censorship, information on the wide scope of the movement seeped into some of the southern newspapers.

In 1897, St. Petersburg students were disquieted by the suicide of Vetrova, a student at the Higher Women's Courses. The government dealt ruthlessly with those who participated in the demonstrations. Many were arrested, some were expelled from institutes, while others were deprived of scholarships. Among those expelled were students of the Mining Institute.

Two years later there was another outburst in St. Petersburg, this time in protest against the brutal beating of a university student by the police. The students of the Mining Institute walked out en masse. The measures taken by the tsarist authorities against recalcitrant students were even more drastic than two years before.

When the students of the Mining Institute quit studies, the Ministry of Agriculture and State Properties issued an unprecedented order dismissing every one of the students and then readmitting only those who were "reliable" (the degree of political reliability was determined by the Institute's Council).

It was not long afterwards that rumours of further student disturbances reached South Russia.

On July 29, 1899, the Minister of Public Education, Bogolepov, endorsed new Provisional Statutes for colleges, according to which students taking part in meetings or demonstrations were to be promptly conscripted for army service. Besides providing for the establishment in Russian higher educational institutions of a rigid system of police surveillance, the Provisional Statutes had other, no

less formidable clauses, designed to entangle the students in a close mesh of police control.

This stringent measure, however, produced results which the tsarist government had not anticipated. The students responded to the Provisional Statutes with stormy demonstrations. The one held by the students of St. Petersburg in Kazan Square on March 4, 1901, was brutally suppressed by the police. Seven persons were killed and 30 injured, and 775 students, including 39 from the Mining Institute, were taken into custody.

Student ferment kept spreading from year to year. On February 9, 1903, the students at the St. Petersburg Mining Institute went on strike.

They demanded the repeal of the despotic Provisional Statutes and their replacement by stable regulations acceptable to students, as well as the readmission of all the students expelled from the Mining Institute for "disorders" since 1889. Another demand was for the trial of the police officials responsible for reprisals against students. The students also demanded the right to personal security, freedom of speech, the press and association, autonomy for all higher educational institutions, and unrestricted admission to college of secondary-school graduates, regardless of sex, nationality or religion.

The student strikers gathered at the entrance of the St. Petersburg Mining Institute on the Neva Embankment and burned the Provisional Statutes while singing revolutionary songs.

The government retaliated by intensifying police terror. About 300 students were expelled from the Institute and the most militant were drafted into the Army.

Such despotism could not but whip up the fury of student agitation. Its repercussions reached other cities of Russia, including Yekaterinoslav, where student ferment also began.

To understand the extent of the student movement in Yekaterinoslav more clearly one should bear in mind that

Yekaterinoslav enjoyed the reputation of a big centre of revolutionary "sedition."

Yekaterinoslav was the hub of a far-flung industrial region. Industrial concentration was naturally conducive to the emergence there of a large number of workers whose disposition, from the official viewpoint, was objectionable.

In those years Yekaterinoslav was distinguished by its revolutionary spirit. A Committee of the Russian Social-Democratic Labour Party (R.S.D.L.P.) had been formed in the city shortly before the turn of the century. It guided the city's proletariat, who more than once militated against the oppression of the industrialists and the police regime.

On the Committee were professional revolutionaries, true Leninists such as Mikha Tskhakaya, Shelgunov and Morozov. The well-known Bolshevik revolutionary Babushkin, a worker, also arrived in Yekaterinoslav after his deportation from St. Petersburg and joined actively in the underground revolutionary movement. Under the leadership of these true Bolsheviks, the Yekaterinoslav proletariat fought for their rights. In the closing years of the nineteenth century and at the beginning of this, the workers repeatedly went on strike and otherwise voiced their opposition.

The scope of the strike movement greatly stimulated the defiant students. If you add the fact that more and more reports of student unrest kept coming to Yekaterinoslav from St. Petersburg, Moscow, Kharkov, and other cities, you will readily understand the lively reaction of our students. From the very first, the history of the Yekaterinoslav Mining Institute became a history of revolutionary struggle of the democratic-minded students.

I witnessed the first major student disturbances at the Institute in the spring of 1901. They began in March and, as the administration stated in one of its reports to the Ministry of Agriculture and State Properties, seriously upset the normal flow of academic life.

Student agitation was curiously described in some of the entries in the Institute Council's journal. An entry dated March 10 read as follows: "On the 9th of March, students gathered in the drafting-room and instead of drawing spent the whole time discussing suspension of studies in other institutes, and, in that connection, the question of quitting studies likewise. The meeting broke up quietly." Another entry, made on March 12, reads: "On Sunday, March 11, the students gathered in the drafting-room and then quietly departed. Today they announced their decision to hold a peaceful strike, pointing out that the cause of this action was not dissatisfaction with the Institute's administration." The Institute's executives learned of this decision from their informers, of whom there were a good many among the students. The "peaceful strike" lasted for about a month and because of it the Institute was temporarily closed.

Within less than half a year, students went into action again. In December 1901, our students made their first move to join the struggle waged by Russian progressives for people's rights. At a meeting on December 11, they protested resolutely against the closing of a number of higher educational institutions by the tsarist government and the conscription of the revolutionary-minded students. That evening they posted the city with hand-written bulletins about the disturbances in Kharkov, and went on strike on the following day. When I came to the Institute in the morning of December 12, I learned that there would be no studies because none of the students had turned up. The Director was informed by student representatives that the decision to strike was taken by an overwhelming vote of 170 to 10.

The students warned that if any of their number attended lectures, the "peaceful strike" might develop into something more serious. The revolutionary leaflets, handbills and humorous verse which began to appear in the Institute aroused even passive students to action.

Young men of Social-Democratic convictions came to the fore as student leaders.

In the morning of December 14, the townspeople saw proclamations posted in the streets. Signed by the Yekaterinoslav Committee of the R.S.D.L.P. and by the newly-founded Organizing Committee of the Yekaterinoslav Mining Institute, the posters were most numerous in the industrial Bryansk and Amur-Nizhnedneprovsk districts. In its proclamations, the Institute's Organizing Committee urged workers to support students and to take part in their demonstration on December 15.

The police were prepared, and on the eve of the demonstration the student leader Kostyushko-Volyuzhanich was arrested and later exiled to Siberia. The brave youth was shot in the town of Chita in 1905.

The demonstration took place despite police measures. Strange as it may seem, it owed its success to the Yekaterinoslav authorities. The city's inhabitants, most of whom had no idea that the demonstration was to be held, learned about it from the announcement of Count Keller, the Governor of Yekaterinoslav. The announcement, posted all over the city on the eve of the demonstration, read as follows: "It has come to my attention that a group of ill-meaning persons are inciting others, with the aid of anonymous letters and other means, to join in the street demonstrations which they intend to hold on December 15 and 16. I hereby declare that I will not stop short of even the most extreme measures to curb any attempt at organizing such demonstrations."

The following morning (December 15), Yekaterinoslav presented a strange sight. Police squads and army units patrolled the streets. Towards 6 p.m. students, workers and artisans, began to gather in the main avenue. It started to drizzle and some demonstrators sought shelter under the awning of the Yefanov Store. The police began to disperse them. Suddenly the whole mass of people on the pavements stepped into the middle of the street and

spread out to the adjoining boulevard. The police attacked the demonstrating students and workers with clubs.

More than 40 demonstrators were arrested. Twenty of them were students. Badly beaten, they were hauled to police stations and thence to prison.

The Institute administration received telegrams from the Governor and the Minister, demanding an explanation of the event and the extradition of the student leaders to the authorities. During those days the Mining Institute seethed with policemen and detectives.

At its emergency meeting on December 17, the Council passed a resolution explaining the reasons for the student disturbances. Referring to the strike, it said: "The Council finds nothing in the internal life of the Institute that can be regarded as an immediate cause of the disorders. A study of several hectograph leaflets found in the Institute warrants the conclusion that the outburst among the students of the Yekaterinoslav Mining Institute was a direct repercussion of the Kharkov events."

After the recess, studies were resumed in haphazard fashion about the middle of January 1902, but not without complications. When they gathered in the Institute, the students asked permission to hold a meeting to discuss the question of resuming studies. The meeting, held on January 15, was a stormy affair. After lengthy debate and furious argument, the students decided to resume studies. Their decision was undoubtedly influenced by the instructions issued a few days earlier by the Minister of Agriculture and State Properties, and enjoining summary dismissal of any student who failed to recommence studies.

You can well imagine the teachers' mood when they began to deliver their lectures, feeling quite certain that student disturbances would break out again in the near future. Their apprehension was justified sooner than expected. The atmosphere in the Institute was very tense. On February 16, about one hundred of our students held

a meeting in the drafting-room. On the following day, the police arrested two of them for trying to hoist a red flag with the inscription: "Down with Autocracy!" in the street. In the morning we learned that several other revolutionary-minded students had been rounded up during the night. Reports of these arrests spread with lightning speed among the students.

On February 20, instead of going to class, the students held another meeting. They told the Director that they had heard that other educational institutions were being closed down and that they wanted to talk to him about the present state of affairs. The students also demanded that the administration intercede with the police authorities in behalf of their arrested comrades.

Once again the Institute Council gathered. Director Suchkov informed us that he had received a letter from the Police Department of February 18, saying that eight students of the Mining Institute had been taken into custody for "unlawful activity" during the night of February 16, and that they would be put on trial. Another three students were detained on the following day. Things, we saw, were taking a bad turn.

On the table was the students' resolution. "We, the students of the Yekaterinoslav Mining Institute, gathered at a meeting on February 20," it said, "hereby resolve to ask the Institute Council to call the attention of the Minister of Agriculture and State Properties to the fact that, although the students arrested on December 15, 1901, have been cleared of all charges, they are still being kept in confinement on the Governor's orders. The police reports were so confused as to exclude one another. Dissatisfied with the treatment of students by the Governor and police, the meeting unanimously requests the release of the students arrested on the night of the 16th of this month, unless their guilt is established. The meeting was attended by 149 persons."

Suchkov did try to persuade the police authorities to

release the students, but his efforts proved futile. The arrested students were deported.

Underground revolutionary organizations continued to function and publish leaflets and proclamations, but studies during the remaining months of 1902 proceeded more or less normally.

Disturbances flared up anew in March 1903, when students learned that two active participants in previous disorders, Kostyushko-Volyuzhanich and Markovsky, had been sentenced to five years' exile in Siberia, and that another student, Kravtsov, had been banished for three years to the Vyatka Province. The students retaliated by calling a protest strike on March 4. The Institute Council tried to suppress the disturbance, but failed. It then resorted to an extreme measure, sanctioned by the St. Petersburg authorities: first-, second- and third year students were expelled and told that whoever wished to return to the Institute would have to submit new applications.

This unprecedented decision was adopted despite the objections of many Council members. Fortunately, most of the students were readmitted.

Studies began in mid-April. Outwardly, things were quiet until early 1904, the year preceding the First Russian Revolution. Tension kept mounting throughout the country and this could not but affect the frame of mind of the students and progressive intellectuals.

Russia's set-backs in the war against Japan intensified popular resentment over the tsarist government's policy. In South Russia, as in other parts of the country, the year 1905 was ushered in by industrial strikes and peasant uprisings to which the students did not remain indifferent. In our Institute, too, the atmosphere was disquieting. The January 9 events sparked off student disturbances that lasted for almost a week. Their significance outgrew the bounds of the campus. In a memorandum to the Ministry, the Institute's Council said that it was "powerless to put an end to student ferment." The interesting thing is that

the Council suggested pacifying the students by introducing "general measures of a progressive nature capable of assuaging the public."

Protesting against the January 9 events, the students quit studies and tried to organize a demonstration, but were dispersed by police. On February 7, the students held a meeting and decided almost unanimously to suspend studies till September 1. Their resolution was worded in a distinctly revolutionary spirit:

"The oppression and despotism that reign in the country, the tyranny and violence that have become a system, poverty and ruin, the profound ignorance of the masses resulting from the arbitrary rule of the autocratic government, the unnecessary and disastrous war, compel every upright citizen of Russia to join the ranks of the people fighting for a better destiny for their country. The government is unwanted and deeply hated by all sections of the population, and to prolong its existence, it resorts to calumny, falsehood and mass murder...."

The resolution went on to list the following demands: immediate cessation of the Russo-Japanese War, convocation of a Constituent Assembly with the participation of people's representatives "elected by universal, equal and direct suffrage by secret ballot," freedom of conscience, the press and association, freedom to strike and to form political coalitions, right of each nationality to self-determination, and prompt release of all those imprisoned for struggling for political freedoms.

We soon learned that the St. Petersburg authorities had decided to meet the "challenge." The Cabinet decided at a special meeting to shut down Russia's higher educational institutions for the time being. Such a ruling testified to the weakness of the autocratic government.

Studies at our Institute stopped but revolutionary ferment did not abate. Early in February, the police arrested all who had attended a meeting held in a private home. According to an Okhranka [Secret Political Police

Department—*Tr.*] report, the meeting was attended by "prominent Social-Democrats of different social standing and professions, headed by engineer V. M. Makovsky and his wife" (Makovsky later won renown as a professor at the Dnepropetrovsk Mining Institute). The report further said that the participants "were reading illegal publications which they tore up as soon as the police appeared on the scene."

But there was no mass action by the students in that period. Early in September, the Institute's administration tried to persuade the students to go on with their studies, reminding them of their "responsibility to their country" and of "the irreparable harm that would result from their abnormal behaviour." But the students were accustomed to disguised threats, and these fresh appeals to their conscience had no effect.

The atmosphere remained tense, and mounted police patrolled the streets of Yekaterinoslav day and night. On September 27, a student deputation called on the Director and told him that a political meeting would be held at the Institute that day to discuss current problems.

The teachers were summoned to an extraordinary Council meeting. To our surprise, it was attended by all the students and a large number of industrial workers. There were about a thousand people in the assembly hall. The Council decided to suspend classes.

Three days later the students gathered in one of the lecture halls and decided to call off the strike they had declared on February 7, but stressed that this did not mean abandonment of previous demands and that, if need be, they would strike again.

The classes, however, were not resumed.

On October 10, after the industrial and transport workers of Yekaterinoslav had called a mass strike, the students held several meetings in the Institute and outdoors. On the following day, barricades went up in the streets and there was a regular battle between the workers

and the troops. A good many of those arrested were students.

On November 7, the Council announced the reopening of the Institute, adding that attendance was not compulsory. It also made several other concessions to the students. This diplomatic move, however, did not produce the desired result. The students continued to stay away.

In those years, there was a so-called Public University in Yekaterinoslav and many workers attended its popular-science lectures in their free time.

In an effort to divert the workers' attention from political struggle, the government tolerated various kinds of institutions "for the enlightenment of the people," on the understanding, of course, that they would engage in nothing that might "prejudice law and order." The University and the Public Lecture Hall were, therefore, in the good graces of the Yekaterinoslav authorities. I used to read lectures at the Public University and became chairman of its executive board in 1905.

In October of that year I was entrusted with the task of organizing a collection of funds for the Yekaterinoslav Revolutionary Workers' Committee. Together with representatives of the city's R.S.D.L.P. Committee, we visited factories. This attracted the attention of the police authorities who accused us of "extorting" money from manufacturers for revolutionary purposes.

All those who took part in collecting funds were thrown into jail on December 20. The eight of us, confined in a small cell, were all in good spirits, well knowing that what we were doing was necessary and useful.

Governor-General Sandetsky, a former commander of the Kazan Military District, dealt ruthlessly with "seditious" intellectuals. I was sentenced to three years exile in the Arkhangelsk Province. My "accomplices" were also punished. It was obvious to everyone and, evidently, to the St. Petersburg authorities too, that the sentences were incongruous with our "crime." On orders from above, my

sentence was commuted to banishment under police surveillance to the town of Ryazan. (I later learned that this was largely due to intercession by the Mining Institute administration in my behalf.)

Thus began the Ryazan period of my life, which, fortunately, did not last long.

BANISHMENT UNDER POLICE SURVEILLANCE

Between 1901 and 1904, when I was working on the compilation of the subject matter which I was to teach in the Yekaterinoslav Mining Institute and which later became part of the general course in mining, I made use of the ample material I had gathered while with the Pastukhov Company and during my trips to other mines in the Donbas.

I was thinking at that time of preparing a thesis for the degree of Adjunct of Science. It seemed to me that if my material were supplemented and generalized it could be of practical use to men employed in mining. Despite the complicated situation, my association with the Yekaterinoslav Mining Institute enabled me to broaden my experience and gather more material, and this amplified my knowledge of the mining industry in South Russia.

As I have said before, the Yekaterinoslav Institute's original system of instruction made it quite different from the other higher educational institutions of Russia. It did not have the traditions of the St. Petersburg Mining Institute, whose founders—Mushketov, Karpinsky, and other distinguished scientists—believed that the student primarily needed theoretical knowledge. The Yekaterinoslav Mining Institute started out with a different, less academic trend. Its aim was to establish as close ties as possible with industry.

It was our belief that advancement of knowledge called for close contact with the enterprises in which our graduates would later work. The Institute's entire curriculum

hinged on that principle, and we never doubted its soundness. In chemistry, mineralogy and some of the other subjects, practical training was compulsory. My first two assistants, V. A. Guskov and M. M. Protodyakonov, and I endeavoured to combine lectures with practical lessons at which students were taught to tackle professional problems.

In the summer-time, Guskov and I accompanied the first- and second-year students when they went out to get practical experience. The Yekaterinoslav Railway placed special cars at our disposal and this enabled us to go straight to the coal and ore fields in which we were interested and to familiarize ourselves thoroughly with Donbas enterprises.

Our tour covered the main Donbas coal fields. The mine managers were always willing to receive students and show them around. We saw how pitching seams were worked in the Gorlovka area and in the Verovka Mine of the Russian-Belgian Company in Yenakievka, and how flat seams were exploited in the Bryansk and Karl mines.

We usually stopped for three or four days at each place, went from mine to mine, examined the equipment, watched operations, and inspected the various surface facilities—preparation plants, coal-tar works, etc. During one of these tours we closely inspected a large chemical plant for refining and processing by-products obtained by coking Verovka coal.

Although brief, these summer trips were undoubtedly very beneficial both to the students and to us teachers. They helped the former better to understand the subject matter of their school studies and gave them a practical idea of the industry in which they would have to work. The teachers, on the other hand, extended their own knowledge of practical problems.

I made good use of all my observations during the visits to the coal fields between 1902 and 1904 when I began to work on my thesis—a big job which I finished in Ryazan.

There isn't much to be said of Ryazan, for at that time it was just one of those quiet little Central Russian towns, in comparison with which Yekaterinoslav was a regular capital.

The thesis I prepared in Yekaterinoslav—"Analysis of the Mining Methods Applied in South Russia in the Development of Coal Beds"—contained more than 500 typewritten pages and over one hundred drawings.

The presentation of a thesis in those days was a more complicated matter than it is now, and entailed troublesome formalities. Firstly, the only place where one could uphold one's thesis was the St. Petersburg Mining Institute, because the Yekaterinoslav Mining Institute, being a young educational establishment, was not entitled to hold such discussions. Secondly, the thesis had to be printed at the expense of the author. Mine was printed in Yekaterinoslav in 1905.

What problems did I try to solve?

Proceeding from my own observations and statistical data on Donbas mines, I set myself the task of analyzing the mining methods used in that coal area and defining the technical and economic criteria by which one can judge the rationality of different methods (longwall, pillar and overhand).

I examined from different angles the various mining operations: haulage, handling, headway maintenance, ventilation, etc., and endeavoured to work out solutions for the problems involved by analyzing the interdependence of such factors as storey-height, size of stoping-room, length of coal face, width of bench, and so forth. I also dealt with the hewers' productivity in development work and coal stoping.

My task was difficult not only because I had to work out many important theoretical mining problems, but also because I had to examine a large number of mining methods. The scientists who had looked into these matters earlier merely described the different methods, but made

no analytical comparisons of the various factors bearing on the intensity of underground workings.

The only exception was the work done by Professor B. I. Boky, one of the leading researchers in mining. His book *Choice of Method in Horizon Mining*, published in 1903, helped me in investigations because he was the first to apply the analytical method to mining. This important method was later developed by Russian scientists engaged in various fields of mining research.

But even though I had such a notable predecessor, I was often faced with the necessity of searching for new answers to many questions.

Mining in those days (fifty years ago) was based largely on applied, "intuitive" methods rather than on scientific appraisal of practical achievement. And yet, the amount of accumulated practical experience and data was sufficient for building up the theoretical foundations of mining technology.

Forward-minded technical experts were searching not for intuitive answers to cardinal mining problems, but for objective scientific solutions based on analytical methods of research. That is what started the analytical trend in mining. The course of events has made it plain that only this trend is practicable and correct, that only an analytical study of all the complex factors influencing the nature of underground workings, makes for progress in the mining industry and in the shaping of mining technology as a science.

We Russian mining scientists are naturally proud of the fact that this important analytical trend, which has always been the main distinctive feature of the Russian school of mining science, originated in our country. In other countries, it was mere empiricism that prevailed in mining science at that time.

I am happy to have contributed a mite to the promotion of that trend.

It was with mounting excitement that I prepared for the presentation of my thesis, for I knew that it would be an "examination" far more serious than the one I took in 1897 when graduating from the Mining Institute. I was aware that many venerable professors, the cream and pride of Russian science, would be present at the discussion. What added to my excitement was that some of the propositions I had to uphold dealt with points on which very little, if anything, had been said in previous publications.

Things were further complicated by my banishment under police surveillance, which practically precluded my trip to St. Petersburg.

The Governor of Ryazan, whom I asked for permission to go to the capital for a few days, took a long time to think it over and then replied: "Sorry, I can't permit it. The matter is too involved. It will have to be referred to St. Petersburg, Mr. Terpigorev." When I suggested that it might be better for me to go to St. Petersburg for the permit, he replied that there was nothing he could do for me and that I would have to wait for written authorization.

The permission of the St. Petersburg authorities finally came in April 1906.

I was thrilled to walk once more through the streets of St. Petersburg, which I had left nearly ten years before. The city was as austere, majestic and cold as ever.

Presenting my thesis turned out to be easier than I had thought. My opponents were of one accord in rating my work rather highly, and, by unanimous vote, the Mining Institute's Academic Council conferred on me the degree of Adjunct of Science and the academic rank of staff professor.

According to tradition, the recipient of a degree had to give two public lectures: one on a subject of his own choice and the other on a subject chosen by the Academic Council. I knew that the Council was in the habit of choosing extremely difficult themes. My worries, however, were groundless. My first lecture was a success—thanks to my

Yekaterinoslav experience. In fact, it was so well received that the Academic Council decided to relieve me of delivering the second lecture.

I returned to Ryazan, but soon I had another opportunity to break away from the monotonous life there and from the police.

For the first time the graduating students of the Yekaterinoslav Mining Institute were going to uphold their diploma projects in public. This noteworthy event was scheduled to be held in June 1906. As the teachers had been crusading ever since the Institute opened to empower it to confer the degree of Mining Engineer instead of Mining Technician on its graduates, the event was significant, and not only for the Institute itself.

I naturally wanted to attend and therefore asked the Institute administration to try, in one way or another, to have me summoned from Ryazan for at least a few days. The administration petitioned Minister Yermolov. This time he proved very lenient, and I was granted permission to visit Yekaterinoslav for the graduation exercises.

My old faculty associates gave me a warm welcome. They told me that during the winter the Institute was often closed because of student ferment, and that classes were resumed only in mid-February.

Although reaction was rampant, the illegal revolutionary organization in Yekaterinoslav continued to exist and exerted some influence on students. But there were no more cases of open manifestation.

The graduation exercises came off successfully. Despite the difficulties with which they had to cope in those days and the fact that they spent more time striking than studying, many students displayed sound knowledge of mining subjects and deserved the Mining Engineer degree they received. It was a big event indeed when the Institute turned out its first crop of engineers. They immediately got jobs in the mining and metallurgical industries, chiefly in South Russia.

After the ceremonies, I returned to Ryazan, but with painful reluctance. Luckily, my enforced stay there did not last long. When the classes were resumed in September, there was no one to lecture on mining in the Yekaterinoslav Institute, and the Council petitioned St. Petersburg, which granted me permission to leave Ryazan.

This time I went to Yekaterinoslav with a joyous heart, knowing that I would not have to come back. The first thing I had to do was to present myself to the new Governor. He gave me licence to resume my teaching job.

BACK AT THE MINING INSTITUTE

The new academic year began normally and life flowed along the usual channels, with lectures and practical studies filling most of the day.

Towards the close of 1906, the students held a meeting, but all they did was to ask the authorities to abolish the percentage quota limiting the admission of Jews to the Institute. With the country in the grip of reaction, their request was, naturally, futile.

Cultural institutions began to appear at about the same time as illegal revolutionary organizations. An amateur theatrical company and several hobby clubs were set up in the Institute too, but their statutes were endorsed by the authorities and there was nothing seditious about their activities. Stringent official regulations barred students from holding meetings, and in June 1907 all their societies were fully placed under the Institute's Council. Despite these drastic measures, student disturbances broke out again at the end of the year, when the Council announced new examination rules. Up till then there had been tests every ten days. It had been quite easy to prepare for them, since they covered only a small part of the course. Under the new rules, exams were to take place only four times a year. That, of course, made things harder for the students

because it obliged them to concentrate more on their studies and to prepare for examinations over a longer stretch of the course.

The students struck in protest, and though the action was not joined by everyone it nevertheless interfered with studies. The students asked faculty members to help them to put through their demands, but though we agreed with some of their arguments, there was nothing we could do about it. The Council went ahead and enforced the new system. Early in 1908, the students held a gathering to demand re-establishment of the old examination system. Even the local press commented on the issue. The Council, however, refused to alter its decision.

At about that time the Institute completed the installation of equipment in its mechanical engineering, electrical engineering and metallurgical laboratories. This was in line with the basic principle of the curriculum—to combine theoretical knowledge with practical experience. Meanwhile, the Institute's Council worked out a plan of introducing laboratory studies in most of the other subjects. It called for the enlargement of the existing and establishment of new laboratories, including a mine laboratory for testing boring and cutting machines, and for experimenting in mechanical concentration of minerals, ventilation, rescue operations, etc.

The Institute also planned to build its own power station and gas plant. The purpose of all this was to help the students to get a sound theoretical background and better understanding of the work for which they were training.

Unfortunately this progressive initiative was also snagged by the indifference of the conservative Ministry officials.

The plan drafted by the Council in collaboration with the faculty was forwarded to the Ministry of Agriculture and State Properties. There it got into the usual rut and travelled very slowly from one office to another. In 1909

it was finally endorsed, but with cuts that left practically nothing of the original provisions.

In 1908 the Institute had to modify some of its curricula because it had become clear that the students had not enough time to cope with all the theoretical and practical assignments they prescribed.

In March there was another student outburst caused by the brutal murder of Dr. A. L. Karavayev, a prominent public figure, by the Black Hundred. On the eve of the burial, the students held a meeting in defiance of the Institute Council's ban, and unanimously decided to take part in the funeral procession and to strike. Many Council members were outraged by the crime that the Black Hundred had perpetrated, and sympathized with the students. But they were wary of voicing their sentiments. The funeral turned into an impressive demonstration, despite the police threat of reprisals, with workers, intellectuals, students and quite a few of our teachers participating. This time the police did not risk using arms.

Shortly after this incident our students founded an underground organization which, as we learned in a roundabout way, was called the Coalition Committee. From time to time it issued leaflets and proclamations, but its activity did not lead to any serious disturbances.

That same year I had another experience of the "courtesy" of the local authorities. I was a delegate to a Mutual-Aid Fund Conference of public education employees of Yekaterinoslav Province. There was nothing subversive about that conference, which was attended by many progressive intellectuals; but the police thought otherwise. One day they arrested everyone at the meeting, including myself, and herded us all to a near-by police station. I must say we were lucky that our captors were the police and not the gendarmerie, for it was much easier to get rid of the former than of the latter.

From the station I was escorted home by a police officer, who searched my place and looked through all my papers.

Later, the Chairman of the Mutual-Aid Fund and I called on Klingenberg, Governor of Yekaterinoslav, to lodge a complaint against the police for breaking up the conference. We used all the eloquence at our command to convince him that the conference had been inoffensive and that the Fund's purpose—mutual aid—was legitimate.

The Governor retorted that there had been many revolutionaries at the conference and that it was not as harmless as we made it out to be. So when all was said and done, we were glad to have got off so easily. The matter could have taken a different turn and landed us in exile.

On September 30, 1909, the Mining Institute celebrated its tenth anniversary. Its very existence in Yekaterinoslav was an auspicious fact. Despite the unfavourable and even distressing conditions of the early years, it graduated several hundred well-trained mining and metallurgical engineers.

Some of the students, however, decided against celebrating. At their meeting they passed a resolution, subsequently published in one of the Yekaterinoslav newspapers, pointing out that in the ten years of its existence the Institute had not done anything to distinguish it from other higher educational institutions. In fact, the resolution continued, its poor equipment, the strenuous conditions in which the students had to study and the sharp antagonism between the Council and the students made the Institute a blot on the already tarnished reputation of the Russian educational system. Taking all that into consideration, as well as the Institute's chronic shortage of funds, there was no justification for spending money on the anniversary celebration, and the students were against it.

That resolution was a typical document of those days, although it did not express the opinion of all the students of our Institute, for less than half of them were present at the meeting. Much of what it said was exaggerated, but the resolution did, to a certain degree, depict the situation as it really was owing to the negligence of the

Ministry. As far as equipment and funds were concerned. the Institute had nothing to boast of, and was indeed inferior to many other higher schools.

The anniversary was celebrated just the same.

Life at the Institute was soon back to normal. Demonstration-rooms for visual and practical study, known as "cabinets," helped the students a good deal in getting a better grasp of mining techniques. We had two of them. The first was organized on my initiative shortly after the Institute was founded, and I was in charge of it for almost twenty years—until the autumn of 1922, when Professor Shevyakov took over.

This cabinet was not badly equipped. Besides models and drawings, it contained specimens of mining machines and tools. The drilling tools, safety lamps, ventilating devices, and other exhibits gave a clear picture of the conditions in the Donbas, which at that time did not have much to show in the way of techniques. The cabinet had a specimen of every new device that appeared in the mines and a valuable set of drawings of diverse mining equipment, a collection of the different grades of coal, ore and rock salt mined in South Russia, and a large number of reports by students who had been out in the coal fields for practical training.

The second cabinet was organized in 1908 by Professor Protodyakonov, and he remained in charge for six years. It was established because the student body of the Institute's mining faculty kept steadily increasing and one demonstration-room proved insufficient. It had drawings, a variety of devices and other visual aids, and some books, but on the whole contained far fewer exhibits than the first.

Another very useful demonstration-room, established in 1902, was used by those studying mechanical concentration of coal and ore. It was managed by V. A. Guskov, a mining engineer, who was my assistant. In 1908, it obtained the first devices for testing the laws governing

the deposition of mineral particles in water. Two laboratories (mine-equipment and minerals) were added to this cabinet in the following year.

The technical backwardness of the pre-revolutionary mining industry was evidenced by the fact that all the devices in the mine-equipment laboratory—hammer drill, hand drill, and drill-type coal-cutter—were foreign-made. But that did not seem to bother the Ministry, which took such things for granted and did absolutely nothing to build up a mining machinery industry in Russia.

In those years some more cabinets were organized in the Yekaterinoslav Mining Institute, devoted to civil engineering, draftsmanship, mineralogy and geology, historical geology, mine surveying, geodesy, and so forth.

One of the best cabinets in the Institute was the metallurgical, established in 1900 by Professor Pavlov, now an academician. It had a library and, later on, sets of drawings on metallurgy. The latter were very popular with engineers and technicians.

All these demonstration-rooms tended to make the Yekaterinoslav Mining Institute one of the most promising colleges in Russia.

My professional work kept me busy through the years delivering lectures, organizing and directing cabinets and laboratories, and helping students to prepare their graduation projects. But that was not the only sphere of my activity. I also devoted a good deal of time to work in the various commissions concerned with developments in the Donbas.

THE RYKOVO MINE DISASTER

As a commission member, I often took part in investigating gas explosions in the Donbas coal mines. In those days no one cared about safeguarding underground workers from accidents. The tsarist government treated very light-

ly the matter of introducing elementary safety measures. The Mining Department, which used to boast of deep concern for the welfare of the miners, actually did nothing to protect them from the perils that waylaid them in the mines. Gas explosions, underground fires and outbursts of gas and coal in the Donbas and other mining regions occurred almost every month, taking a heavy toll of life. The bereaved families were given niggardly hand-outs, and the persons responsible for the disaster went unpunished.

The improvement of safety measures was an urgent necessity in the Donbas, where many coal beds were saturated with gas. In 1901-06 about one hundred of the mines there were gaseous. Many miners were killed in the big explosion at the Ivan Colliery (Makeyevka District) in 1898. Open lamps were the cause of at least thirteen explosions between 1901 and 1906. The introduction of "safety lamps" did little to improve matters because they were not always reliable. The situation was too dreadful to be ignored, and mining engineers and researchers tried to work out theoretical and practical ways of preventing explosions, and to make mining safe. A series of articles of mine on this subject appeared in the *Gornozavodskoi Listok* and other periodicals. I wrote about the need to establish a methane-testing station in the Donbas, dealt with the problem of safety lamps and the use of safe explosives in gaseous mines.

All discourses on safety programmes, however, proved as futile as a voice in the wilderness. Mine-owners and Mining Department officials agreed with our arguments, but took no practical steps to reduce the danger of underground work. Explosions continued to be as frequent as ever.

In 1908, I went to the Donbas as a member of a government commission to investigate the causes of a terrible explosion in the Rykovo Mine near Yuzovka. The conditions in which the miners had to work were appalling, and I saw once again how utterly indifferent the mining authorities and the government were to their safety and welfare. I arrived at the scene a few days after the disaster, which was

a result of criminal negligence on the part of the operators. The news of this atrocity spread like wildfire through Russia and beyond her borders.

It was the system of labour organization, typical of all Russian mines for many years, that brought about the catastrophe. The explosion occurred on June 18. The shift taking over at 2 p.m. totalled 388 persons. Eye-witnesses told us that the miners were depressed and complained of the rotten state of affairs at the mine. They felt that more and more gas was accumulating, but the management paid no heed to that. The miners went down and for about five hours work went on as usual. At about seven there suddenly came a rumble from underground, followed by three terrific explosions. Old miners said they had never heard blasts of such violence. Several men standing at the hoist near the mouth of the shaft were thrown into the air. Flames leaped out of the shaft and everything shook as if from an earthquake.

One can imagine how the families of the victims felt at that moment. The management, thrown into confusion, did not know what to do. Someone telephoned to Makeyevka for a rescue squad, but it arrived only at 10 p. m. The management, it appeared, did not even have a plan of the mine, and it was only because some men had worked in the mine before and knew its layout that the rescuers could get started.

In such a big disaster life-saving operations should have been organized on a large scale. The primitive efforts of the small squad, which did not even have enough rescue devices, were really pathetic. It took a long time before 19 devices, some of them out of order, were collected at various mines. This fact alone showed how indifferent the mine-owners were to the safety of their workers.

Much time went by before respirators and other rescue apparatus were brought in from neighbouring mines, and it was only late at night that the life-savers got down to the scene of the disaster. What they saw was a mass of rock

and coal which had buried the miners alive. In some places, the mixture of methane and coal dust had caused spontaneous ignition and started underground fires.

It took four days to retrieve the bodies of the 270 dead miners. They were interred in common graves not far from the colliery, and the funeral was attended by miners from all over the district. The cortege was nearly two miles long.

People thought that those responsible for the crime would be brought to justice, but, as usual, they were not.

The conclusion drawn by our commission was a serious indictment not only against the mine operators, but the whole Mining Department as well. Although the management did not deny its blame, it was unperturbed by the heavy toll of life and, being certain of impunity, treated the whole thing rather calmly.

Investigations established that the explosion had been caused by faulty ventilation. Witnesses testified that the miners had repeatedly warned the administration that the ventilating system was out of order. The latter, however, did not care to spend money on repairs, even though these would have cost very little. The amazing thing was that on the very next day after the disaster everything was back in the old rut, not the slightest move having been made to reduce the hazards to which the miners were exposed.

Neither the mine-owners nor the authorities responsible for the crime suffered any punishment. Paltry sums were handed out to the bereaved families as relief, and Tsar Nicholas II donated 20-25 rubles to each family.

The question of investigating the causes of the explosion in the Rykovo Mine was raised in the State Duma on June 24, six days after the disaster. The reactionary majority, however, saw no need for appointing an investigating commission, claiming that it would be enough if Vice-Minister Konovalov went to Yuzovka and reported on his findings. The "unpleasant matter" was quashed.

I had occasion to investigate other accidents in the Donbas, some of them rather disastrous. The interesting

point is that in all of them the causes were invariably the same: negligence and inertness on the part of the mine-owners and managers.

I now marvel at the fine and safe working conditions that have been created for miners under the Soviet system. Indeed, we now have a scientific institution—the only one of its kind in the world—devoted entirely to improvement of safety in the mines. It is the Makeyevka Research Institute of Labour Safety in the Mining Industry, located near the scene of that terrible explosion of 1908.

I made frequent trips to the Donbas and that enabled me to follow closely the evolution of the old coal region and the changes taking place there over the years.

PRE-REVOLUTIONARY DEVELOPMENT OF THE DONBAS

Little is known of the history of the Donbas in the first decade of this century, so I think it is worth dwelling on some of the developments of that period, which affected technical equipment, coal production, and so forth.

Besides the factors I have already mentioned, the development of the Donbas was stimulated by railway construction. The Donets line, linked with the Azov and Kozlov-Voronezh-Rostov lines, was opened in 1878. The building of this line led to the sinking of more mines. Although coal production kept increasing steadily, only 7,215 kilometres of track were laid in 1900-05, as compared with 14,877 kilometres between 1896 and 1900. Coal output rose from 11 million tons in 1900 to 25.3 million tons in 1913 and kept rising throughout the World War I years. The number of workers in the coal fields increased accordingly. The many villages around the mines supplied cheap labour and that was one of the main reasons why mechanization progressed so slowly.

Professor P.I. Fomin writes in his book *Economic Survey of Russia* that in 1904 there were 78,000 miners in the Donbas, in 1907—117,000 and in 1912—141,000. In 1913 the number went up to 168,000 and in 1914 to 186,000. The Donbas was becoming a major industrial area.

Between 1893 and 1913, coal ouput increased six and a half times, whereas in other areas it only trebled. Oil output in the same period rose only 72.3 per cent, and the total world output of solid fuels went up only 150 per cent.

Another important development in the Donbas was the invasion of the coal industry by big companies. In 1893 there were 13 such companies, producing 50 per cent more coal than all the other mines taken together, state-operated included. In 1912, their number increased to 36 and their combined output was nearly three times that of all the other mines. Over 80 per cent of the coal mined in 1912 came from big pits, each producing more than 160,000 tons a year, whereas small pits with annual output below 16,000 tons accounted for only 4.6 per cent. The chief consumers of Donbas coal at that time were the metallurgical industry and railways.

In 1910 I took part in organizing an industrial and agricultural exhibition in Yekaterinoslav. Among the exhibits characterizing conditions in the mining and other industries in the Yekaterinoslav Province were models of the machinery used in coal mining. All of them were, of course, foreign-made. Also displayed were charts and diagrams tracing the development of the Donbas and other mining areas in South Russia.

One of the diagrams showed that the Donbas produced more bituminous coal than anthracite. That was because the operators were naturally interested in mining coal that was easier to market. According to another diagram, only 15 per cent of the coal mined was processed into coke and briquette.

Nowadays much of the coal is processed. More than 200 derivatives used in the chemical industry are obtained from

the coking process alone. But in those days little use was made of the chemical derivatives of coal, even though a good many collieries had their own coking facilities.

There was a chart showing the big tracts of land leased in the Donets Basin by mine-owners. Some of the land was purchased, but most of it was rented. About 2 per cent of the land on which mines were developed was in the Don Army Region. The Don Cossacks would not sell it and the lease contracts specified that on their expiration they could take the land back with the mines and structures. Such provisions, of course, did not encourage investment.

Large collieries with an annual output of approximately 100,000 tons naturally employed more miners. Average annual productivity per man, according to one of the diagrams, did not exceed 170 tons. In the large mines the productivity rate was higher than in the small ones. The big companies obviously had more experience in organizing production efficiently. In the bituminous mines the productivity rate per man was higher than in the anthracite mines. The exhibition gave a good idea of the distressing living conditions in the Donbas.

There were many interesting displays on the expansion of other branches of the mining industry, particularly ores, in South Russia during the first decade of this century. Ore mining was concentrated chiefly in two places—the Krivoi Rog District and Kerch Peninsula. Earlier ore was also mined in the Donbas and in Korsak-Mogila but the deposits there were almost exhausted by 1910-12. Krivoi Rog and Kerch were the main suppliers of ore to Russia's iron and steel mills.

At that time, the Krivoi Rog District produced approximately 5,000 tons of ore per annum. As in the coal industry, the bulk of the output was provided by big joint-stock companies, which supplied five times as much as the mines operated by individual owners. Annual output in the Kerch District was only 400 tons, or less than one-twelfth of the

Krivoi Rog figure. All the mines there belonged to companies. It is worthy of note that the iron mines in Krivoi Rog employed about 20,000 men and those on the Kerch Peninsula, not more than 500. It was only later that the Kerch mines somewhat increased their proportion of the total output of iron ore.

The salt industry was then centred in the Bakhmut District of Yekaterinoslav Province. It produced both rock salt, and salt obtained by evaporation. Here, too, rock salt production, which reached the impressive figure of more than 320,000 tons by 1910, was in the hands of five big capitalist companies operating six mines. The largest of these companies, the Rock-Salt and Coal Mining of South Russia, was the leading monopolist in that part of Russia, accounting for nearly 50 per cent of the total salt output.

Other exhibits illustrated the distribution of coal and ore among consumers and the condition of Russia's economy. Strange as it may seem, Russia imported coal – some 5 million tons in 1912, e.g. (I am uncertain about the figures for earlier years.) Why did Russia have to buy expensive foreign coal since she mined plenty of coal of her own? Well, it was because economically tsarist Russia was in large measure dependent on foreign capital.

The main consumers of Donbas coal were railways and metallurgical plants, but much of it was shipped to other parts of South and Central Russia and the Volga Area, where solid fuel was fast replacing oil. This process was just as important as that of coal superseding wood fuel.

Most of the ore mined in South Russia was consumed by metallurgical plants in the southern and other parts of the country, and about one-sixth was exported. An issue heatedly debated in the press and elsewhere at the time of the Yekaterinoslav exhibition was that ore exports should be banned because they retarded the development of Russia's steel industry. The demand to prohibit these exports grew ever more vocal, but the government agencies con-

cerned paid little heed to it because they were interested in increasing ore shipments to other countries. They claimed that the Krivoi Rog deposits were inexhaustible and that exports could not affect home production. This argument revealed the attitude of government agencies and certain industrial circles towards the development of Russia's metallurgical industry. The tsarist government and many capitalists were interested more in importing diverse machinery than in developing the engineering industry, and the latter, including mining machinery, remained in a rudimentary state.

One of the exhibitors at the Yekaterinoslav Industrial and Agricultural Exhibition was the Produgol Joint-Stock Company, which sold Donbas coal. Founded at the time when the Donbas was rapidly gaining in importance, the Company was a vivid illustration of the factors that governed fuel distribution. In 1900, coal prices were high, to the satisfaction of mine-owners. The railways paid 10 to 12 kopeks per pood. Demand was greater than supply and a certain amount of coal had to be imported. But in the next year the slump in Russia's metallurgical industry cut the mills' consumption by about 25 per cent and caused a sharp drop in prices. A pood of coal fetched only 7 kopeks and then as little as 6.5 and even 5.5.

In 1905, the railways took only 2.7 million tons of Donbas coal. The slump in the oil industry, however, boosted the demand for coal, and in 1906 they bought over 4 million tons at 8-9 kopeks. The Produgol Company was founded in the spring of 1906, when the demand for and prices of coal increased sharply. It was established with the aim of stabilizing prices and protecting the interests of the mine operators. Yet, when certain consumers abruptly changed their plans to suit their own interests, the Company proved its inability to keep prices stable. In subsequent years, the railways again reduced consumption of Donbas coal because the state found it more profitable to switch partly from coal fuel to oil.

It did not take long to realize that the Company's efforts to stabilize coal prices in capitalist conditions were naïve and futile. In short, the venture miscarried. Many were surprised at the Company's set-backs and thought them transitory. But they were actually due to the very nature of the capitalist economy, which is based on ruthless competition. The government was unable to regulate prices and there was no way of planning the economy. Some progressive-minded leaders in industry and mining were aware of it, but there was nothing they could do.

The situation I have just described has persisted to this day in the capitalist countries.

SURVEY OF THE DONBAS MINES

In 1914, the Mining Department, alarmed by the large number of accidents in the Krivoi Rog mines, set up a special commission to investigate safety techniques there. I was on that commission and went to Krivoi Rog together with Professors A. A. Skochinsky and M.M. Protodyakonov. First we inspected open-cut and then underground workings.

During my trips and summer excursions with students to the Donbas, I had collected a large amount of data. All this material had to be generalized.

In 1912, Protodyakonov and I began to work jointly on an extensive monograph which we named "Description of the Donbas." It was published in separate volumes in 1914-22. I wrote two of the volumes, one of which was in two parts. They treated of the problems of coal mining and haulage.

The compilation and publication of the monograph were decided upon and subsidized by the Council of the Coal Producers' Congress of South Russia. It was a treatise

similar to the one on the Rhine-Westphalia coal fields which appeared at that time in Germany. A special programme designed to expedite the collection of data on the Donbas appeared in the form of a large book.

The monograph was the first endeavour to generalize a vast amount of factual information characterizing the deposits of our country's largest coal area. We tried to give as complete a picture as possible of its economic structure and technical facilities. It was a difficult task, for the little that had been written on the subject before dealt only with certain aspects of the area's economy. In compiling the monograph, we studied a vast amount of statistical, graphic and descriptive material. I still wonder how we did such a tremendous job.

I will not say that all the credit for the monograph belongs to Professor Protodyakonov and me. We were assisted by many engineers employed in the mines, and this made our task much easier. Besides statistical and other materials, they supplied many descriptions and drawings of the mines. All this material was to have been analyzed by several prominent mining experts, but actually the work fell to Protodyakonov and me. The scope of our work may be seen from the fact that the three volumes, which came out in six instalments, contained over 2,600 large-size pages of text and many drawings.

The first volume appeared in 1914, the second in 1915, and the first instalment of the third in 1918. I managed to get out the second instalment of the third volume in 1922, despite the difficulties our country was going through. Unfortunately, the valuable monograph was never completed. Nevertheless, I find it gratifying that the factual data of the published volumes were widely used in planning new mines and their equipment, and in part introduced in various text-books and mining manuals.

Some of the equipment I saw in the Donbas when making a study of the various mining methods was of a nature

that nowadays can be found only in museums. One of the contrivances was the heavy, cumbersome and inefficient plunger-pump, worked from the surface. This unwieldy device consisted of drain-pipes and a steam-engine, which raised and lowered the plungers at the end of a rod inside the vertical pipes. Because of its great dimensions and auxiliary appliances, the plunger-pump occupied a separate building. It was soon replaced by the more modern and less cumbersome centrifugal pump of greater efficiency.

Equally ponderous were the Gibal ventilators, also installed on the surface. Together with the bulky but not very serviceable piston compressors, they too are now museum pieces.

The crude machinery of the pre-revolutionary era was of little avail in improving working conditions in the mines. To reach the coal face, the miner usually had to walk down a sloping entry some 200-300 metres long. The steam pipes, laid in most cases along the entry, leaked at the joints and sometimes raised the temperature to as much as 40°C. And while it was exhausting to walk down this drift, walking up was agony. I often saw workers dripping with perspiration as they returned to the shaft after their arduous ten-hour shift.

The management did practically nothing to lighten working conditions underground. There were no means of transportation in the galleries. At best, the sloping main workings had steps cut in the floor. The water trickling down the steps covered them with slime, and it was all one could do not to fall, for there were no hand-rails or anything else to hold on to.

Most mines were aired by a natural draught. Only a comparatively small number of gaseous mines with a high emission of methane were equipped with ventilating systems as required by safety regulations. In some drifts very simple contrivances, sometimes made of wood and operated by hand, were used for ventilation.

Lighting in the mines, as I have already said, was very poor. Smoky, open lamps with cotton wicks were used for many years, even though they were very dangerous.

The working conditions in the Donbas mines hardly improved between 1903 and the Revolution of 1917. The only improvements were in the way of equipment: some mines replaced steam-engines with electric motors, wooden headframes with iron ones or with frames of reinforced concrete, and piston compressors with the more efficient centrifugal compressors.

Nevertheless, mechanization was progressing very slowly. Winding engines of the old type were replaced by engines with large cylindrical drums, and sometimes by more modern models with conical or bicylindrical and conical drums. Mechanical drills were introduced for making bore-holes. Only hand drills had been used before, but in 1905 compressed air was put to use instead of hand feed. I saw pneumatic hammers only in a few mines, among them the Yenakievka mines belonging to the Russian-Belgian Company. Some of the big collieries began experimenting in cutting machines about 1908. The first machine, I was told, was used in one of the British-run mines in the Alexandrovsk-Grushevsky anthracite district. It was a "Diamond" model of the disc type. Although the coal-cutter was advertised as the "latest technical novelty," it was not fit for use in our mines. American machines of different types were also imported at that time. There were approximately 120 coal-cutters in the Donbas during World War I, and though they were of different makes, they were pretty much the same. None of them was suitable in our conditions, their effectiveness was insignificant, for most of the time they stood idle. Nevertheless, nothing was done either by the mine operators or the Mining Department to have the unproductive foreign machinery replaced with more efficient machines of Russian design and make.

As a result it was costlier to mine coal with machines than by hand, for labour was cheap. I saw many machines

A. M. Terpigorev, professor of the Yekaterinoslav Mining Institute. 1917

standing idle in storage, not so much because they needed repairs as because the mine operators did not care to use them.

While certain improvements were introduced with regard to equipment, extracting and hauling remained practically the same as 20 years earlier. Gradually the wooden tubs were replaced by steel cars of small capacity (not more than half a ton) and trains of these cars were hauled by locomotives instead of being pushed by hand. The mining industry kept expanding and there appeared bigger and more productive mines.

In the thirty years of their development the Donbas coal fields increased output 18-fold, reaching 25.3 million tons in 1913. In the next three years output climbed at an even faster rate. The 1914 output was 27.5 million tons, and in 1916 it reached the peak figure of 28.7 millions. It goes without saying that the number of miners increased too. There were 168,000 men employed in the mines in 1913, 186,000 in the next year, and 238,000 in 1916. Production declined sharply in subsequent years, and it took a long time before the output of the 1914-16 boom period was again equalled. The restoration of the Donbas began only in 1922.

EVE OF THE REVOLUTION

Towards the end of the war more and more students began to realize that it was the imperialists who had started it and that they were the only ones who wanted it to go on.

A student co-operative was organized in our Institute at the time, engaging, among other things, in Bolshevik agitation against the autocracy and the imperialist war. The teachers knew it was a sort of semi-legal club for discussing current events in Russia and primarily reports from the front. Pseudo-patriotism began to yield to the re-

alization that the rotten tsarist regime had to go. The slogan "Down with the Tsar!" became more frequent in illegal publications and at student meetings.

The progressive students of our Institute established contact with workers and soldiers. We learned of the February Revolution in Petrograd on February 28, the day the local liberal newspaper *Pridneprovsky Krai* carried an article on the overthrow of the tsar. The students held a stormy meeting at which they hailed the workers and soldiers of Petrograd who had begun the revolt, and decided to get in touch with the capital as soon as possible so as to have a fuller and more truthful account of the revolutionary events. They promised to support the Provisional Government in establishing revolutionary order in the country, but no one seemed to know what that order should be like. It was only later that the events were sized up correctly.

There was a small group of reactionaries in the Institute, but they were soon silenced by the revolutionary-minded students. The faculty members were hazy about the situation and therefore commented on the events with discretion. Their appeals to the students to remain calm and orderly were futile. At Council meetings there was plenty of excited discussion and argument but no agreement. Professor V. M. Makovsky, who had been called "an old revolutionary" to his face and behind his back by both students and professors, was the only one to hail the revolution unhesitatingly.

At their meeting on February 28, the students elected an Executive Committee to direct student affairs and their participation in the revolutionary movement. They also chose representatives to the city's public organizations. Resumption of normal studies was out of the question.

News got around that there was commotion among the Yekaterinoslav workers. Outwardly everything seemed to be just as it had been before: the governor, the chief of police

and the garrison commander remained at their posts, the police continued to patrol the streets with an air of dignity, as if nothing had happened. This ostentation of tranquillity, however, could not conceal the confusion of the city authorities.

Events developed fast and practically every hour brought fresh reports on the collapse of the tsarist regime. On March 2, representatives of the Yekaterinoslav workers came to the Institute and there was a big meeting. After the meeting some students were assigned to the Andrushchenko Print-Shop in Staro-Dvoryanskaya Street to help in printing proclamations calling on the workers of Yekaterinoslav Province to hold elections to the Soviets of Workers' Deputies. Other students were entrusted with the maintenance of public order. Workers and students disarmed the police in the streets and took over all the stations and posts. The newly-established militia consisted mostly of students. The students' Executive Committee maintained close contact with the revolutionary proletariat, and the Institute became an armed camp. Many teachers were carried away by the events, and it no longer surprised anyone that soldiers of the local garrison gathered one day for a meeting in the lecture hall of the chemical faculty or that delegates from the local factories met in another lecture hall.

Studies were gradually resumed, and the students broke up into a larger number of political groups. Among them were Bolsheviks, Socialist-Revolutionaries, Mensheviks, Popular Socialists and Constitutional Democrats. Bolshevik influence was growing steadily. At the time of General Kornilov's counter-revolutionary putsch, in which the bourgeoisie rallied all its forces against the proletarian revolution, there was a distinct division between the Liberals, the Constitutional Democrats and motley "Socialists," on the one hand, and the revolutionary students who supported the Bolsheviks, on the other. These students joined the mighty

demonstration held in Yekaterinoslav in protest against the Kornilov rebellion.

In 1917, I began delivering lectures at the Kharkov Commercial Institute. Later I headed the Ministry of Trade Commission in Kharkov which granted loans to South Russian operators for capital construction in the mine fields. But that did not last long. The counter-revolutionary nationalists managed to establish themselves in South Russia, and soon after the Ukraine was occupied by the Germans.

My engineering and teaching work was interrupted for a long time.

PART TWO

As I look back upon the eighty-two years of my life, sixty of which were devoted to my profession, I see that it was a long course consisting of two unequal parts, each of which had its distinctive significance. The 38 years since the triumph of the October Revolution have been the most creative and essential. In this period I have succeeded in doing far more than I had done before, though I was a mature engineer and active in public affairs even before the Revolution. It is a great satisfaction to live and work when you know that the country's entire resources are used for the good of the people.

For that reason I would like the reader to understand the emotion and sense of gratification with which I retrace our great country's progress during the post-revolutionary period. I am especially happy to see the amazing headway our mining industry has made. It is comforting to realize that the Soviet Government is giving so much attention to the advancement of mining science, and that we are doing exceedingly well both in prospecting and in using our mineral wealth.

The radical improvements achieved in the mining industry under the Soviet system would have taken a hundred years to achieve under different conditions. It has been my good fortune to witness the impetuous growth of our mining industry and to take part in carrying out some of the vital measures aimed at developing our country's coal

fields, particularly in the Donbas. I can therefore see how much has been accomplished. Viewing the second lap of my career from that angle, I am distinctly aware that it has been much fuller and richer than the first, pre-revolutionary, period of my activities as an engineer and teacher.

MY RETURN TO YEKATERINOSLAV

During the last few years before the Revolution I devoted myself entirely to educational work and research—drafting the lectures I delivered in the Institute and devising scientific methods of instruction. I had planned to write and publish some books, but did not get around to it because of the strain of that period.

Owing partly to the chaotic economic and political conditions in South Russia, and partly for family reasons, I moved in 1919 to Rostov, and later to Sevastopol.

The defeat of White Guard General Wrangel gave me a chance to return to my professional occupation. After the liberation of the Crimea, the Donbas ceased to be a battleground. As soon as the Soviet regime was established in Sevastopol, I was invited to help in surveying fuel resources and delivering lectures at the Sevastopol Polytechnic School. But I soon learned that studies had been resumed at my old Mining Institute and I returned to Yekaterinoslav.

Some of the old professors were no longer there, and there were new teachers whom I did not know. I asked everyone to tell me how things at the Institute had been during the troublesome years when the city was in the hands of Hetman Skoropadsky and of Generals Petlyura and Denikin.

When I returned, the Institute was still in a bad state. It had very little money, the laboratories and libraries were in a sorry condition, part of its property was gone. The professors, teachers and employees were not getting

their salaries. All the professors received was a scanty food ration.

There were three Communists at the Institute and they formed the first Party group. A political commissar was appointed, the rector was replaced by another, and gradually things began to get into shape.

On the teaching staff of the Institute at that time were V. P. Nikitin (electrical engineering), who later became an academician, Y. I. Grdina (prominent in theoretical machanics), Professors N. I. Lebedev, S. A. Zaborovsky, P. G. Rubin, N. A. Ivanov, P. M. Leontovsky and V. M. Makovsky, and a group of talented young scientists, including L. D. Shevyakov, A. M. Tseitlin and N. S. Polyakov. Besides conducting courses, they helped graduating students to prepare their diploma projects.

By decision of the Council of People's Commissars a Workers' Faculty was set up at the Institute towards the end of 1921. Its purpose was to train skilled personnel for the coal fields in the Donbas and other parts of Russia. Professor Makovsky, entrusted with organizing this new faculty, soon found the required premises, equipment and teaching staff. The 110 freshmen were chiefly Donbas miners, and they turned out to be very eager and diligent students.

Meanwhile, studies at the Institute were going normally. The students sedulously attended lectures and practical training classes, and worked on their diploma projects. It was a difficult period but the Institute did a good job of training mining engineers.

In the autumn of 1922 I went to Moscow and that radically changed my life. There had been a lot of talk in Yekaterinoslav about the new Mining Academy in Moscow, which was referred to as a new type of higher educational institution. At the beginning of the academic year I unexpectedly received an offer to take charge of the Academy's mining chair. It is interesting to note that many of my friends tried to persuade me not to go because, they said, the Academy's position was very shaky. I even got a let-

ter from one of my Petrograd Mining Institute friends, cautioning that the Moscow Mining Academy was "built on sand" and likely to collapse and advising me not to take the risk. That opinion was shared even by veteran professors. Time proved, however, that they were all wrong and that the Academy was destined to play an important role in Russian mining history.

Anyway, I made up my mind to accept the offer and in November 1922 I moved to Moscow. That put an end to my 22 years at the Yekaterinoslav Mining Institute, and ushered in the period of my teaching and scientific career in Moscow, a career which has continued to this day.

THE FOUNDING OF THE MOSCOW MINING ACADEMY

The reason for all the scepticism about the Mining Academy evidently stemmed from the fact that the issue of establishing a higher mining school in Moscow had long been a controversial one. The first reports about it had appeared in the papers several years earlier, when the question was raised by coal producers in South Russia at their Second Congress in April 1917. A resolution passed then emphasized the necessity of setting up a mining institute in Moscow. At the same time, though quite independently of that resolution, the Ministry of Trade and Industry received a petition from the students and teachers of the Warsaw Politechnic Institute, which had been moved to Nizhny-Novgorod during the war, requesting that the Institute's mining faculty be transferred to Moscow. The idea was to transform it into a faculty of the Moscow Higher Technical School. The plan failed. Although the petition was supported by the Technical School and the Moscow Merchants' Association, which was then very influential, the Ministry, disturbed by the revolutionary upsurge, turned it down.

Thus, the only hope was for Moscow to establish an independent mining college. This idea was welcomed by the District Mining Administration and various public organizations. The Moscow City authorities promised to provide a lot for the college campus in the Neskuchny Park. But the matter got so tangled up in the countless commissions set up by the bureaucratic machine of the Ministry of Trade and Industry that it eventually was killed by red tape.

Shortly after the Great October Socialist Revolution the question of establishing the Mining Academy as the first higher mining educational institution of the new-born Soviet Republic came up again. Despite the adverse conditions in the country, despite the famine and economic dislocation, the matter was soon settled. On Lenin's instructions, an organizing committee was set up to draft a decree on the institution of the new college. At one of its meetings in 1918, the Council of People's Commissars thoroughly discussed the draft. I have been told that Lenin, who presided at the meeting, strongly favoured the project and stressed the importance of training a large body of mining engineers. But as the Moscow Region was not the only coal area in need of a higher mining school—the Urals and the Ukraine likewise needed one—Lenin proposed establishing a competent commission of representatives of the Ural and Ukrainian mining industries, the People's Commissariat of State Control and the People's Commissariat of Finances, to pass final judgement on where to found the Mining Academy—in Moscow or some other city.

After detailed deliberation, the commission unanimously arrived at the conclusion that the Mining Academy should be established in Moscow.

On September 4, 1918, the Council of People's Commissars issued a decree over Lenin's signature on the institution of the Moscow Mining Academy. One of the points made in the decree was that the miners of the Moscow Coal Basin were in need of technical education and that

the Republic was in need of highly-qualified engineers and researchers for the metallurgical and mining industries. It was specified that the Academy should be organized jointly by the People's Commissariat of Education and the Mining Department of the Supreme Council of National Economy, that it should function in accordance with its statutes, and should be administered and financed by the People's Commissariat of Education.

At that time our country was resisting the onslaught of the combined forces of fourteen imperialist nations and was suffering from an acute shortage of everything down to paper and ink. And it is indicative of Lenin's great perspicacity that even in those trying days he saw that our country would need a vast force of mining experts.

According to the decree published in the *Izvestia* on September 15, 1918, the Moscow Mining Academy was to have three sections: instructional, academic and scientific. The first was to familiarize miners with technological achievements and to train mining engineers and technicians. The scientific section was to work on essential problems of mining and metallurgical engineering and related scientific subjects, and to direct the activities of the Academy's research institutions. The academic section was to be the higher mining school proper.

The first thing to do was to find suitable premises for the Academy, and that was not easy. The government assigned two buildings, but both were then occupied. One of the buildings, in Bolshaya Kaluzhskaya Street, was vacated by the end of 1918. The other, a palace in Neskuchny Park, was eventually turned over to other claimants.

When the Moscow Mining Academy opened on February 12, 1919, it had three faculties: mining, geological prospecting and metallurgical, and a teaching staff of 19, including four professors and five docents. It had practically no equipment and its financial position was precarious.

But the teachers knew how important it was for the country to have a new higher educational institution unfettered by old traditions, and that stimulated their energy and enthusiasm.

The Academy set up a number of qualification classes and courses for people employed in the mining industry, and they existed for almost three years—until the opening of the Workers' Faculty in the first half of 1922. Towards the end of 1919, the Academy also organized several schools in different parts of the Moscow Coal Basin—a school of prospecting and drilling techniques at the Pobedinsky Colliery, courses for miners at the Yepifan Station, and a school in Tula for training mining technicians. All this is evidence of the broad scope of the programme undertaken by the Academy, which at once began to build up close ties with the mining industry.

The original curriculum called for a three-year course, it being assumed that the enrolling students would be well grounded in all the general subjects, have sound, advanced knowledge of higher mathematics, physics, chemistry, theoretical and applied mechanics and drafting, and would, therefore, need instruction only in special subjects. But the plan did not work because there were not enough applicants sufficiently prepared to meet such stiff requirements. Most of them had forgotten many of the theoretical subjects and, of course, could not cope with the special courses. For that reason prep courses had to be introduced from the very first year.

The Academy began enlisting the assistance of distinguished scientists and mining experts, and this was expedited by the gratifying fact that various economic bodies and the Miners' Union started allocating funds for laboratory equipment. At first things were not very smooth and many claimed that the Mining Academy was built on sand and would not last long. The Academy soon proved its viability, and silenced the pessimists.

The administration persuaded the newly invited educa-

tors that with support from the new generation of students, who were free of distrust and prejudice towards their teachers, they could speedily make the institution a leading scientific and educational centre for training skilled mining personnel.

A good deal of credit for building up the Mining Academy and enlisting the co-operation of outstanding scientists and educators is due to its first rector, the late Academician I. M. Gubkin, an eminent geologist and oil expert. By attracting a strong force of competent teachers, he helped to make the Academy one of the country's foremost educational institutions. The students were workers and farmers with a great thirst for knowledge, many of them coming straight from the Red Army. This influx of new blood and the well-chosen faculty enabled the Academy to outstrip all the other mining colleges.

The Academy's tenth anniversary was marked by the issue of a special one-day newspaper under the title of *From the Depths of a Mine to the Summit of Knowledge*, carrying an article which retraced the early years of the Academy. "What facilitated the Academy's success and how did it advance towards its main objective?" asked the author, I. M. Gubkin. "Its first aim," he answered, "was to ensure a careful selection of students in line with the lofty principle that knowlege should be vested in the working people. Consequently, most of our students are workers, or the children of working people, and a goodly half are members of the Communist Party or the Young Communist League. Such a composition of the student body continuously vitalizes the revolutionary spirit which has always distinguished our Academy, and for which it is rightly called a 'Red Academy.' The maintenance of this revolutionary spirit is stimulated by the Academy's constant association with miners and metal-workers. Its closest ties are with the miners, who regard the Academy as their own creation."

THE ACADEMY'S TRAINING METHODS

When I moved to Moscow in the autumn of 1922, the Mining Academy was already going strong. On its faculty were Academician A. D. Arkhangelsky, the famous geologist V. A. Obruchev, my old friend M. A. Pavlov, a leading expert in metallurgy. Professor M. M. Fyodorov, and many other prominent scientists. Instruction was based on new methods. In our quest for them, we naturally erred sometimes. For instance, the training programme, designed to meet industrial requirements and fit the conditions in which the future mining engineers would have to work, underrated the importance of a sound theoretical grounding.

We rambled a good deal before finding the best form of instruction by lecture. At first it was proposed to abandon the old lecture method in favour of the so-called complex-group method, whereby students concentrated on a certain group of interconnected subjects and studied them by the seminar system for a definite period, usually six weeks. This method, it was believed, would enable the students to get a better grasp of the subject matter.

For a while this method seemed to produce good results, but we soon realized that it was not the right way to teach if we wanted to turn out engineers well trained both practically and theoretically. So we later switched back to the old and sufficiently tested lecture-and-seminar method which, of course, is the better way of training specialists.

Putting the curricula into effect, we came face to face with diverse problems concerning the organization of the educational process. The best solutions did not always come at once. In the year when I joined the faculty, the executives and teachers arrived at the conclusion that a special body was needed to co-ordinate and direct the entire instructional procedure, and so, in 1923, there emerged a so-called instruction-planning commission. Looking back, it is easy to see that such an artificial body was

useless, but at that time we thought it was a noteworthy accomplishment and would justify itself.

I still have a copy of the handbook which the Pro-rector of the Academy, V. A. Obruchev, compiled for students in 1922. It contains a good deal of interesting information on the Academy's activity at that period. In describing the different faculties, the author used colourful words to stimulate curiosity. For example, those wishing to enrol learned that the mining faculty trained people "for the responsible job of mining engineer" and that "this fascinating work is for men of courage and imagination, men who are ready to face danger in wresting mineral wealth from the earth's grip, who like the thrill of exploring the mysterious darkness of underground labyrinths, and who are anxious to pit their resourcefulness against the subterranean foes of the miners—floods, fires, explosions and earth displacements." Such tempting appeals were hard to resist.

According to the handbook, the fundamental subjects which every engineer, regardless of his speciality, should know, were taught during the first year in all the three faculties: mining, geological prospecting and metallurgical. They were higher mathematics, physics, crystallography, chemistry, theoretical mechanics, draftsmanship and drawing. Besides, each faculty had its special subjects. In the geological-prospecting and mining faculties, freshmen learned the rudiments of mining and geodesy and took a general course in geology. Botany and topography were taught additionally only in the geological-prospecting faculty. The curricula were different from the first year no not only because the specialities were different, but also to make it harder for restive students to switch from one faculty to another.

At the end of their first year the students went out for practical training. They began with geodetic survey, then studied geological field methods and spent the last few weeks of the summer training period working in col-

lieries as miners, getting acquainted with working conditions underground, the structure of mines, their equipment, etc. All this stimulated the students' interest in their future profession.

Students of the metallurgical faculty took no training in geodesy or geology but spent the whole summer in steel mills watching the smelting, casting and other operations. This well-organized system of summer practice did the students a lot of good and was, in fact, an essential element of the training programme.

As I said earlier, the students at the St. Petersburg and Yekaterinoslav mining institutes also engaged in practical training during the summer, but the pre-revolutionary system was far inferior to the one introduced by the Moscow Mining Academy. Rid of the old traditions, the Academy completely altered the nature of practical studies, as well as the entire educational process. Instead of semesters, the academic year was divided into trimesters, during which theoretical and practical studies alternated regularly. On the whole, there was much more time set aside for practical instruction both in classrooms and laboratories, and that was the main factor which eventually made the Academy a model for all old colleges. Mining and other institutes began to copy our system.

At that time, the Academy's mining faculty trained engineers in three special lines: engineers for mining coal, ore and various other minerals, both metallic and nonmetallic; engineers for the oil industry, who specialized in oil geology, methods of drilling and oil-field development, and the technology of processing petroleum into gasoline, illuminants and lubricants and other products; and engineers, who specialized in designing and installing diverse mining machinery and equipment—hoists, pumps, ventilators, compressors, excavators, etc. There was always a big demand for mining engineers familiar with underground and open-cast mining methods and machinery.

During the 1922/23 academic year, the Moscow Mining Academy was still in a stage of organization and therefore the curricula of its faculties and the time allotted for various subjects changed quite often. The only thing that did not change was the high proportion of time devoted to practical training. For their summer practice after the first- and second-year, the students engaged in geological survey and prospecting and learned much about their future work in the mines, oil fields and metallurgical plants. After the third year, they spent their last summer-practice period gathering material for their diploma projects.

During these years our young Republic was having a hard time and therefore the teachers and students worked and lived under trying conditions. Famine hit the country in 1921 and the food rationed out to students was barely enough to live on. Teachers' rations were also inadequate. Vigorous measures were taken to improve the situation and soon it did improve.

Another difficult problem was that of providing the Academy students arriving from all parts of Russia with living quarters. There was a terrific scramble for every available house in Moscow, and it cost a great deal of effort to get a building and furnish it for the first student dormitory. It was a large six-storey house in Staromonetny Street, owned before the Revolution by the Marfa-Marya Monastery. In 1920, it was occupied by the Central Statistical Board, but it soon moved to another place. The Mining Academy applied for it at once, but so did other institutions. The matter was referred to the Council of People's Commissars and eventually there remained only two claimants: the Academy and the Second Moscow State University. At that time the students were returning from summer practice and about a hundred of them had to be quartered in the Academy's large drafting-room. Soon after, the government authorized the Academy to take that building over for a dormitory. The point I

want to make is that even in those troublesome years the government was always ready to help new educational institutions.

I visited the dormitory on several occasions in 1922 and 1923 and saw the hardships that the students had to put up with. There was no mess-room and they had to line up before the kitchen range to cook their own meals. There was very little fuel and sometimes it was so cold that water-pipes froze. Most of the time the students went undernourished. Their craving for knowledge, however, was so great that the hardships could not affect their studies.

In the early twenties repeated attempts were made to retard the growth of the Mining Academy. Its value was questioned many a time, but the Academy invariably proved its worth. The issue that came up again in 1924 was whether there was any need for the mining and metallurgical faculties. One of the plans was to abolish both these faculties and the Academy as such, and reorganize the oil faculty as an independent oil institute. I. M. Gubkin stood up successfully for the Academy. With all the obstacles surmounted, the Mining Academy continued to flourish and to prove to its opponents that it was viable and useful to the national economy. Every year it produced a bigger crop of young, well-trained engineers and geologists who went out to the mines, oil fields and steel mills in different parts of the country to help in refashioning its industries along socialist lines.

REHABILITATION OF THE DONBAS

I would now like to return to 1921-22, when I was assigned an important job. Upon my return to the Yekaterinoslav Institute in 1921, I learned from my colleagues that the government was launching a big rehabilitation programme in the war-scarred Donbas. Lenin was giving the matter close attention. I was eager to help with the

job, and welcomed my appointment as a member of the State Commission set up to draft the programme. I worked on the Commission till October 1922.

Although output in the Donbas had increased steadily during World War I, reaching the peak in 1916, no new coal beds had been developed. During the Civil War the young Red Army fought furious battles with the counter-revolutionary forces in the Donbas. The region was occupied by the Germans and by the Petlyura and Makhno bands, who ruthlessly wrecked the mines and other enterprises. Lenin pointed out then that the damage was too great to estimate. We saw how true that was when our Commission inspected the coal fields. We found the mines in pitiful condition. Most of them had been blown up or flooded. In those still operating, production was very low. The 1920 output was only 4.5 million tons as against the 28.7 millions in 1916. All of the 65 blast-furnaces in the Donbas had been wrecked during those four years, and the number of men employed in the mines had dropped very sharply. The job of rehabilitating the Donbas was a tremendous one, but it had to be done as quickly as possible because the economy of the Soviet Republic was in a critical state and no recovery was possible until the fuel shortage was overcome.

It was then that Lenin, addressing the First All-Russian Constituent Congress of Miners, said that after winning a military victory there is yet another, a more difficult victory, to be won. Stressing the vital importance of fuel to the country, he said that in order to save the Soviet system the industries had to be fed with coal and that unless that was done the national economy could not be restored, the railways could not function and the factories could not produce the goods which the peasants wanted in exchange for grain.

The Donbas miners made a heroic effort to increase production and in March 1920 succeeded in doubling the

January output; in October, output went up to half a million tons. But despite this valorous endeavour, coal output was still far below the pre-war level and too small to meet the demand. It was clear that the selfless work of the miners was insufficient to bring about a sharp increase in output and that the problem must be tackled scientifically. There was an obvious need for an over-all plan for the rehabilitation of the entire Donbas and development of new coal fields. Only then would the basin be able to supply coal in sufficient quantities to meet the Soviet Republic's economic requirements.

Towards the end of 1920 the government set up a Donbas Commission of representatives of all the Commissariats concerned with the rehabilitation and development of the national economy. This Commission concentrated on priority tasks with a view to raising productivity in the coal fields. It gave particular attention to improvement of the miners' living conditions and food supply. A Provisional Conference at the Council of Labour and Defence (C.L.D.) was set up under F. E. Dzerzhinsky's chairmanship to help in solving cardinal rehabitation problems.

A one-month drive to help the Donbas was launched in January 1921. Trainloads of mine equipment, food and clothing came from all parts of Soviet Russia. The crop failure that year caused famine in certain parts of the country. There were times when workers in the Donbas and other areas had to get along without bread for several days at a stretch. For that reason many quit the factories and mines to move to the country. The number of hewers in the Donbas dropped from 16,000 to 10,000; coal production diminished accordingly. But the miners who remained succeeded in overcoming the difficulties. In April 1921, the papers reported, over 70,000 persons in the Yuzovka District worked voluntarily on Sundays and produced more than 16,000 tons of coal. That was a heroic deed, rated as important as a victory in the Civil War,

and the Yuzovka miners were decorated for it with the Orders of the Red Banner. Although such instances of enthusiasm on the part of the masses were numerous, it was evident that radical improvement could be achieved only by restoring all the mines.

A State Commission for Drafting a Rehabilitation Programme for the Donbas was set up according to a decision of the Council of Labour and Defence, which Lenin signed on May 27, 1921. In its resolution the C.L.D. stressed that the drafting of a substantiated plan for the rehabilitation of the coal industry in the Donbas was a matter of exceptional state importance and urgency. The Commission's duties, as outlined in the resolution, were: a) to examine the technical and economic condition of the mines, to determine their present and potential output capacities, and take stock and make a technical assessment of all the soft coal and anthracite deposits; b) to work out an outline plan for achieving maximum production in operating mines, provided their present equipment is in good repair and additional equipment is made available to them, and to draft a programme for increasing coal production to 24 million tons by 1926.

It was further stipulated that the People's Commissariat of Railways would place one sleeping car and ten freight cars at the disposal of the Central Board of the Coal Industry for the Commission's use and that these cars could be hitched to any express, passenger or freight train. This was an important point, for railway service at that time was in a bad state and it was very helpful for the Commission to have their own means of transportation. Our cars were parked on the side-tracks of mine and factory lines and this saved a lot of time in inspecting the coal fields.

When we read the C.L.D. decision, we realized that the members of the Commission had been charged with vast responsibility. We also saw in it an indication of Lenin's foresight, his particular ability of looking beyond im-

mediate problems. It made us proud that we had been entrusted not only with the drafting of the Donbas rehabilitation programme, but also with planning its future development.

In its work, the Commission availed itself of the survey made in the summer of 1920 by a group of mining experts headed by Professor B. I. Boky. After inspecting the Donbas coal fields, they established that more than 1,600 so-called production units (mostly small pits) could be liquidated without retarding the growth of output capacity.

There were four other professors besides myself appointed to the Commission as members or advisers—Shevyakov, Skochinsky, Rubin and Boky. The first three collaborated actively, while Professor Boky, unfortunately, was unable to take part in the Commission's work.

Our first assignment was to give an opinion on a plan for surveying the Donbas and on a set of questionnaires which were to be filled out in the mines. We reported favourably on both the plan and the questionnaires and only added a few remarks, suggestions and explanatory notes dealing with the development of coal beds and with coking, briquetting and chemical processing. The Commission proceeded from the coal production increase figures fixed by the Central Coal Committee.

There was a lot to be done because the survey had to be a detailed one: we had to inspect every mine without exception, examine the conditions of all shafts, headings, pit bottoms, drifts, slopes, surface structures, etc., and estimate the potential output of each mine. It meant that every member of the Commission had to inspect some 40-50 mines, and that he and his assistants had to go through approximately 100 kilometres of underground passages, for at that time their total length in the Donbas mines ran to about 10,000 kilometres. It was a titanic job, but no one shrank from it, and in the summer of 1921 we went off to the Donbas.

DRAFTING THE REHABILITATION PLAN

The Donbas was divided into nine areas and these were apportioned among the members of the Commission. My share was the Krindachevka area embracing the mines of the Fashchev, Shterovka, Khrustalsky, Bokovo, Shchetovo and Rovenki districts. L. D. Shevyakov inspected the mines of the Yenakievka area. A. A. Skochinsky had no particular area to investigate, but helped to generalize the data collected by the Commission. P. G. Rubin's assignment was to inspect all of the basin's coke-ovens, briquette factories and plants for processing the by-products derived from carbonization of coal.

We ran into difficulties, partly of a technical nature, from the very start. Many of the mines had no plans of underground workings, nor of new developments, surface structure arrangements, underground railways, etc. Geological data were inadequate or lacking, and there were no analyses indicating the grades of soft coal and anthracite obtained by sorting and washing. Quite often there was no information at all on the types of equipment and engines used in the mines, and very little information on electrical equipment. In some districts the data on employment, productivity of labour, and so forth were very scanty and incomplete.

Besides these difficulties there were complications of a general nature, so to speak. For instance, many mines were short of skilled technical personnel and there was no one to answer the Commission's questions.

Furthermore, we found it troublesome at times to move from one place to another, even though the Commission had its own railway cars. In those cases when the spur tracks of a mine could not be used for one reason or another, the only other way of travelling was by horse. But horses were scarce in those days, and fodder was still scarcer. Besides, such travel was dangerous because of the bandit gangs operating in the Ukraine, especially in

the Almaznaya, Yenakievka, Fashchev and Dolzhanskaya districts.

The mines were grouped according to districts. Most of the big collieries were idle; a good many of them were flooded. District commissions were formed to inspect the mines thoroughly. The Commission I headed included two engineers and two graduating students. We had an ordinary freight car at our disposal, which we jokingly called "our saloon-car." We had it hitched to passing trains and unhitched where we wanted to stop.

We sent our reports regularly to the Central Board of the Coal Industry in Bakhmut (now Artyomovsk). The members of our Commission got a good deal of help from the Central Committee of the newly organized Miners' Union, whose first chairman was Artyom, a prominent Bolshevik. At his suggestion workers' meetings were held in the mines, and we reported to them what our Commission was doing.

Our group did not miss a single mine in the Krindachevka area and, if I remember correctly, inspected more than 200 of them. Very few were in need of reconstruction, but many mines were so small and unproductive that they were not worth developing. We found that only 42 had sufficient deposits of coal. Seventeen collieries were flooded and had to be restored. On the whole, the picture was not so bad; anyway, it was better than in other districts.

In our calculations we mentioned everything required to raise coal production to the pre-war level: equipment, machinery, structures, skilled personnel—from miners to engineers. And while not all the estimates were equally important, nor all the facts indisputable, the Commission had gathered ample material on which to base a rational, integrated plan for the rehabilitation of the Donbas coal industry.

The idea was not so much to raise output in the operating mines as to restore the collieries that had been flooded and wrecked. In some of them millions of cubic metres

of water had to be pumped out. In 1921-22 when technological standards in the coal industry and other branches of the national economy were low, this problem was an extremely difficult one.

The plan adopted was not to drain the flooded mines but to work the seams under them by leaving a protective layer of rock. To this end it was suggested that shafts be sunk lower or that new ones be started.

A peculiar thing about the mines we inspected was that they used coal slack salvaged from muck dumps as fuel for their steam-engines, and also to heat service and living quarters. Near the mines there were mountains of coal slack which had never been used before, but in 1921-22 the slack was put to good use. Sometimes coal dust and chippings were pressed by hand devices into small cylinders. The slack was no longer regarded as waste but as a good substitute for anthracite.

The Commission took pains to find out which mines could be worked at once and which required capital repair. Pieced together, the data from the nine districts investigated gave us a clear picture of what the situation was like in both the bituminous and anthracite coal fields. I would like to emphasize that we inspected each mine very thoroughly to determine its reserves of coal, as well as the actual condition of the workings. The object was not to draw up a "summarized" report on the state of the coal fields but to define the condition and capacity of each production unit.

The Commission inspected 287 anthracite and 641 bituminous mines in the Donbas. They were divided into five basic groups. The first consisted of collieries found to be most suitable for exploitation. This category included operating mines with ample or limited reserves, and some that had been shut down for one reason or another. In the second group were small mines of limited usefulness for working upper seams only, with the use of horse gins or steam hoists. There were many such mines in the Donbas.

Listed in the third group were the abandoned, inactive mines. The mines of the fourth group were those which the Commission found advisable to liquidate. The fifth category was composed of new shaft sinkings which could be regarded as new deposits.

Most of the mines investigated in the Krindachevka area belonged to the first group. They were either capable of producing or could be easily restored. Next in number were the small mines with horse or steam-engine windings. Only four shafts could be regarded as new sinkings.

Of the 287 collieries inspected in the anthracite fields, 107 were already producing, or could be easily set going. Forty-nine were in such condition that they had to be liquidated. The rest were small mines with steam hoists, or else belonged to the category known as "peasant mines" —small pits worked by peasant artels with primitive tools.

In the soft-coal areas 178 of the 641 collieries inspected by the Commission were either operating or restorable, and 36 had never been worked.

It was hard fully to assess the available coal reserves, for a good many of the small shafts with horse gins or hand winches were in a really sore state. Besides, output capacity in some mines had to be estimated very approximately because of the bad state of the underground workings. Nevertheless, the State Commission drafting the Donbas rehabilitation programme wound up its job with fairly good results. That was due not so much to the completeness of the information which its members had gathered as to the persistence with which, despite all the difficulties, they had worked on their important assignment. We all realized how essential it was to revitalize the country's leading coal basin and, therefore, tackled every obstacle with redoubled effort.

When the district commissions had completed the inspection of the collieries, coke-ovens and other installations in their respective areas, they submitted detailed reports which showed that the coal fields had suffered badly

during the Civil War. Although many mines were still operating, their output was extremely low, and there was very little in the way of reserves.

Our conclusions stressed the immensity of the job that had to be done in order to restore the Donbas to its pre-war production capacity. We drew up two alternative rehabilitation programmes—maximum and minimum. The maximum variant required a large outlay to attain an annual coal output of 24.5 million tons within 5 years.

The Commission figured that in 1922 and 1923 the mines could produce only a third of the 1916 output—approximately 9.6 million tons a year. To raise output to 24.5 million tons, the state had to spend nearly 147 million rubles on reconstruction of mines, building of new installations and purchase of additional mechanical equipment. Supplementary expenses, according to the maximum variant, would bring the total to about 390 million rubles, more than half of which would go to improve the miners' standard of living.

The minimum variant contemplated a production increase to 20 million tons at a total cost of only 178 million rubles.

Today, such capital investment in the development of the country's main coal region would not seem so big, but at that time, when there was so much devastation throughout the country and when a tremendous effort was needed to repair the damage and put the national economy back on its feet, the amount looked enormous. Our Commission's conclusions were found to be sound and valuable and were used as the basis for an over-all plan to rehabilitate the Donbas.

The drafting of the rehabilitation programme, however, was not the only assignment our Commission had. There was another task of no lesser importance—to find new coal fields, prepare a full geographical, geological and economic description of the deposits, and map out the boundaries of the coal beds.

There were rumours abroad at the time that concessions of Russian coal fields would be granted to foreign capitalists. That was something the Soviet Government had no intention of doing. When our Commission had begun surveying and searching for new coal beds, the foreign companies which may have sought concessions soon realized that their ambitions were hopeless.

The maps which we then drew of the new coal deposits in the Donbas were so complete that they have not lost their significance to this day. They showed the approximate boundaries of coal blocks, the dimensions of carboniferous areas, as well as their distribution in relation to old mines, quarries and metallurgical plants.

To each map we appended a detailed description indicating the position of proved seams, the grades of bituminous coal or anthracite, the initial and maximum depths of the deposits, the number of shafts it was proposed to sink in each coal block, the estimated duration of the supply, and also the distances between the future mines and the nearest loading points.

The survey revealed 189 new Donbas coal fields, of which 104 were in soft-coal areas and 85 in anthracite areas. The data which we had collected came in very useful during the first and second five-year plan periods of economic development. They served as a basis for the long-range programmes under which the Donbas made splendid progress and contributed substantially to the expansion of the country's coal industry.

EXPANSION OF THE MOSCOW MINING ACADEMY

By 1925 the Moscow Mining Academy was one of the best-known and most reputable educational institutions in the Soviet Union. True, rumours kept cropping up regularly that it would be moved elsewhere or closed altogether, but it continued to improve and expand. Among the

new facilities were demonstration-rooms and laboratories devoted to theoretical mechanics, physics, heat engineering, machine parts, material testing, electrical engineering and chemistry.

These laboratories with their primitive equipment would probably seem very small and inadequate to the student of today, but to us they were veritable research establishments. What our facilities were like then may be seen from the fact that all the equipment of the mathematics cabinet, including books, cost only two hundred rubles. The equipment of the physics, heat engineering, and some other laboratories was somewhat better. The demonstration-room of machine parts was very helpful to students who took a course in mechanical engineering.

In those early years our socialist industry was just getting on its feet and all laboratory apparatus and instruments had to be imported. But as our industry developed they were gradually replaced by devices and instruments designed and made at Soviet factories and of local materials. The demonstration-room for coal-cutting machines, which, by the way, was one of the oldest in the mining faculty, at first had only two machines, both foreign-made—the Pickwick and Sullivan models. Soviet coal-cutters appeared a few years later.

Besides the practical training facilities for the use of the Academy as a whole, there were facilities for the various faculties. The mining cabinet and the Mining Museum, later named after this writer, were set up along with the Academy itself. The Museum exhibits consisted of odd parts of drilling instruments, a few models made by students, and a small number of mining tools and apparatus. The Museum was in such chaos that it looked more like a lumber-room than a collection of mining exhibits.

At first the cabinet and the Museum were in a bad state, but growing allocations soon made it possible to equip them fairly well. Among the study aids in the cabinet

were tables and charts on coal haulage, mechanized mining, drill prospecting, etc. The students added a good deal to the Museum exhibits. Every time they went to the coal fields on assignments or for practical training they arranged to have a variety of mineral samples, specimens or equipment and mine models turned over to the Museum.

I dwell at length on the equipment of our laboratories and cabinets because those were hard times for our national economy, and the acquisition of a new apparatus or visual aid was therefore quite an event. Our teachers and students greatly appreciated the equipment we had and took good care of it. I cannot help comparing our facilities in those days with what we have now. We could not imagine then that we would one day have an educational institution like Moscow University on the Lenin Hills, where the laboratories are equipped with apparatus which is not always available in research institutions—equipment worth millions of rubles.

Today's students of the Moscow Mining Institute, who find the splendid collections in our Museum so useful, probably have no idea how hard it was to get them together. The first exhibits were imported models of drop shaft timber, watertight partitions and life-saving equipment. In 1924, our Museum received a valuable collection of drilling tools, tables and models from the Kursk Magnetic Anomaly Administration, plus a set of mine ropes and cables and several cage models from the Gorlovka Mining Administration. That year the Museum already had more than 400 items. In 1925, the collection was supplemented with some models and devices from the Industrial Exhibition of the Supreme Council of National Economy and with samples of life-saving devices and safety lamps from rescue stations in the Donbas. Nowadays, all these antiquated devices can be seen in museums only. More exhibits were received from the Donbas in 1927, including a Draeger life-saving apparatus of the latest type and a set

of control instruments. We were especially glad to have them, for they were the last word in safety technique. A life-size model of a drift in a coal pit, with stope face, props, rail track, etc., was installed in the Museum in 1926. Another life-size model was that of a mechanized heading in a flat seam, with a coal-cutter and a conveyor. Students and teachers, and visitors to the Academy, would queue up in the Museum to see our "natural stope." By 1927 the Museum had a valuable collection of mining equipment, including a complete set of drilling tools. By October 1928 there were 800 exhibits, or twice the 1924 figure, illustrating Soviet industrial progress fairly well.

Besides helping to train our own students, the Museum rendered valuable assistance to the students of other Moscow colleges: the Industrial Academy of the Supreme Council of National Economy, the Plekhanov Institute of National Economy, and the Moscow Polytechnic School.

The teaching staff increased along with the number of specialities taught at the Mining Academy. Far-reaching measures were taken in 1926-28 to expand the mining faculty, which eventually became the leading faculty. The need for competent mining engineers was growing and that confronted the Academy with the problem of improving its training programmes. The Academy also began training engineers for the oil and peat industries.

In the summer of 1928, our Academy underwent a number of changes in accordance with a government decision. On July 28, it was transferred from the People's Commissariat of Education to the Central Board of Higher and Secondary Technical Education of the Supreme Council of National Economy. This was done "for more effective co-ordination between the system of technical education and the requirements of the industries" and was an important step towards improving the system of engineering education.

THE FIRST ALL-UNION MINING CONGRESS

Our coal industry, ravaged by two wars, was getting back on its feet pretty fast in the mid-twenties. Mining engineers and researchers realized that it was time to sum up the results achieved and, more important still, to lay down a definite course for the near future if the coal industry was to progress. The job of fully rehabilitating the leading coal fields was not always carefully planned, though a long-range plan for the rehabilitation of the Donbas had been drawn up in 1921. The need now was for a well-substantiated programme for the development of the country's coal industry as an integral part of the contemplated industrialization plan.

The Supreme Council of National Economy, which directed the restoration and development of Soviet industry, set up a permanent bureau entrusted with holding scientific and technical congresses and publishing their proceedings. The bureau was headed by I. M. Gubkin, and I was one of its members.

The First All-Union Mining Congress, which opened on April 14, 1926, was of major importance to the mining industry, and I will therefore deal with it in some detail. I remember how excited we were as we gathered in the Hall of Columns of the House of Trade Unions. Attending were the country's foremost experts, among them professors Protodyakonov, Shevyakov and Skochinsky.

The Congress was opened by I. M. Gubkin. "The building of the new life confronts our generation with titanic problems," he said. "Mining is the keystone of our national economy.... Coal, oil and iron are the main pillars of our heavy industry. The government is concentrating on extensive development of our industries, including mining. Industrialization will be co-ordinated with agricultural development. The task of the coal industry is to produce enough coal to meet the country's growing demand. To achieve it, we will have to reorganize our coal industry."

The next to speak was a veteran Russian geologist, A. P. Karpinsky, the first post-revolutionary president of the Academy of Sciences, who read the Academy's greetings to the Congress. He was followed on the speakers' platform by F. E. Dzerzhinsky, one of Lenin's close associates, who was heard with the greatest attention. Outlining the Party's cardinal directives on the country's economic development, he said: "In mining, as in the other branches of our economy, the important thing is to reconstruct it in accordance with the latest developments in science and engineering. The only way to ensure swift progress in mining is to electrify, mechanize and rationalize production, and to apply the principles of scientific organization and standardization."

The chief problems facing the Congress were formulated by Dzerzhinsky with the utmost clarity. He stressed that smooth work required stronger links between theory and practice, adding that it was up to the Congress of the mining engineers and researchers, and of the key men in the industry, to consolidate these links. The Congress thus laid the groundwork for the co-ordination of mining practice and theory, the result being a veritable technical revolution in Soviet mining.

The tasks assigned us by the Party and the Government were clearly outlined also in an address by the eminent Party leader, M. I. Kalinin. But before dwelling on his vivid speech, which I remember quite well even though I heard it more than thirty years ago, I would like to digress a little.

I had the pleasure of meeting Kalinin several times and got to know well that able statesman who came from the very thick of the masses. Though he was very busy with affairs of state, he always found time to discuss the problems on which scientists sought his advice. They often visited his office in Mokhovaya Street in Moscow and always met a cordial reception. In Kalinin they had a sympathetic and authoritative adviser and a fair if strict

judge, who helped them to untangle the most involved questions. He was an implacable foe of bureaucracy, overt or covert. He gave prompt and thorough attention to the numerous requests that came from all over our vast country.

His finest qualities were exceptional modesty and an exacting attitude towards himself. One always saw that he was above all else a servant of the people. This was manifest in practically everything he did—in the way in which he would rise from his desk and cross the whole length of his reception-room to welcome a caller, in the cordiality with which he received visitors. It was with really touching courtesy and amiability that he would move up an arm-chair and seat his visitor comfortably so as to remove all constraint from conversation. He had a way of winning his listeners by elucidating the most complicated questions in a simple yet vivid manner.

I first met Kalinin at a meeting held on February 12, 1923, to mark the anniversary of the Mining Academy. At the meeting, he made a speech to which we, the professors who still remembered the "traditions" of the old mining school, responded enthusiastically. In plain words and with apt comparisons he explained why it was necessary to debunk the notion that science should be made a fetish of, and why it should be made accessible to the masses of the people as soon as possible. His words impressed me very deeply, for they provided answers to questions that had arisen in the course of my work as researcher and educator. It was very important for us teachers to hear that from one of the leaders of our Party and Government.

The second time I heard Kalinin was at a meeting of the students and teaching staff of the Mining Academy on September 25, 1925. Again his words left an unforgettable impression. With the same unaffected eloquence and vividness, he advanced the proposition that students should organize their work well because they were faced

with the serious problem of training for executive jobs in their chosen fields of science and engineering. This implied, he pointed out, that besides studying theory, the students should accumulate practical experience as organizers. And the only way they could do that was by taking part in social and political activities. Kalinin's idea had so strong an appeal that we made it an integral part of our later work with the students. Needless to say, those propositions retain their validity to this day. They have been confirmed by the entire experience of our higher schools.

But to return to the First All-Union Mining Congress. That was the third time I heard Kalinin speak. His speech was of prime importance to the engineers and technicians who had gathered from all over the young Soviet Republic, as well as to the scientists and educators representing various colleges and research institutions. We listened with keen—I would even say avid—attention, and were profoundly stirred by his words that "there is nothing more gratifying than to be aware that you are building and that your creative effort benefits the people, the workers and peasants."

It should be remembered that these words were spoken at a time when some of the industrial experts belonging to the old intelligentsia were not overzealous in devoting their abilities and knowledge to the building of the new life, and when some even resorted to counter-revolutionary sabotage. For that reason, Kalinin's definition of our role in the common creative effort stimulated those specialists of the old school who sincerely devoted all their knowledge to the promotion of the well-being of their people.

The audience warmly applauded Kalinin's closing words: "I have no doubt that the mining engineers and technicians, the miners, the captains of heavy industry, which sustains the capitalist world's might and which here in Soviet Russia should be the mainspring of the strength of our Soviet state, fully realize their mission

and responsibility and will fulfil the task assigned them by history."

Kalinin's address focussed the attention of his audience on the need for accelerated progress, and stimulated the enthusiasm of thousands of engineers, technicians and scientists, participating in the reconstruction of the mining industry.

Reports delivered at the Congress dealt with the state of affairs in the country's leading coal fields, with ways of developing the coal industry, and with means of expanding and improving secondary and higher education in mining technology, geological survey, and so forth. My two reports treated of a five-year plan for the development of the Donbas and the training of mining specialists.

As I have said above, part of the plan for the rehabilitation of the Donbas was carried out in 1923-25. Nevertheless, output was still low. In 1925-26, the Donbas produced only about 20 million tons of coal. A long-range plan drawn up at that time provided for the sinking in the Donbas of big mines capable of meeting the demand for high-grade coal over a long period. These new mines —of which at least thirty were to be sunk in 1926-27 and more than 130 big and small collieries, in the following five years—were to be extensively mechanized.

It was an important aspect of the plan that it provided for large-scale mechanization of mining. Heavy cutting machines were to be used. This marked the beginning of a technical revolution in the Soviet coal industry. It was planned to mechanize haulage as well, and the media considered most efficient at that time were conveyors and scrapers. Up till then coal had been hauled in workings in cars. Under the new haulage system cars of larger tonnage were to be used on the main roadways only, and were to be drawn by trolley or battery-powered electric locomotives.

Another process to be reorganized was the hoisting of coal to the surface. Coal of non-crumbling grades was to

be transported in large tip-up steel boxes called skips. These skips would get their load from automatic measuring hoppers and then discharge it, also automatically, into bunkers on the surface. To keep lumps of anthracite from breaking up, coal cars were to be secured fast in tipping cages. For this purpose the pit bottoms had to have more complex equipment for the automatic caging and uncaging of cars. In some mines, endless rope haulage was to be used in pit bottoms and adjoining drifts for large-tonnage cars. At anthracite mines, mechanized storage platforms were to be built for the automatic handling of different grades of anthracite and for loading it into railway cars. All mine shafts were to be reinforced with concrete or brick, and up-to-date electric battery lamps were to be used for underground illumination.

I have dwelt on these details to show the course mechanization and electrification were to follow in the reconstruction of the Donbas. They indicate that even at that time our projects outlined the main elements of the modern, highly-mechanized colliery. The planners, who took account of future progress in Soviet technology, acted more boldly than their counterparts abroad. The immediate future proved the plan to be perfectly realistic. As we shall see later, radical reconstruction of the Donbas coal fields on the basis of mechanization and electrification went on at a rapid pace.

Despite considerable difficulties, our mining schools and colleges successfully trained technical personnel for the coal and other mining industries. The technological reconstruction of our mines naturally called for a greater degree of technical control and supervision and induced our mining schools to train more engineers and technicians. There were 1,100 engineers employed in mining, and the number of rank-and-file miners was then 330,000. The aim of the First Five-Year Plan was to increase the number of mining engineers to 2,700 and of technicians, to 5,400.

In those days the U.S.S.R. had six colleges for training coal, ore and oil engineers. They were the Leningrad and Dnepropetrovsk mining institutes, the Moscow Mining Academy (later reorganized into a Mining Institute), and the mining faculties of the Don and Urals polytechnic institutes and of the Siberian Technological Institute. They all had the same curriculum and term of study, and graduated engineers of equal qualification. There was also a mining faculty at the Stalino Technical School which trained mining engineers of narrow speciality. In 1926, these mining colleges had a total enrolment of 1,966 students. The largest number—484—were at the Moscow Mining Academy. During the preceding five years, they had graduated 1,102 mining engineers, or 70 per cent of the number needed.

Some alleged then that there was an "overproduction" of mining engineers. As a matter of fact, the situation was just the opposite; there was a shortage of engineers and especially technicians, and in order to train more, the number of mining schools had to be increased. The technician-engineer ratio was only 1.3:1, and that, of course, was much too little. In tsarist times the technicians were, at best, graduates of mining trade schools. But most of them were promoted miners with plenty of experience but no special schooling. The increasing scale of mechanization made it imperative for technicians to have a theoretical background. Satisfactory progress could not be made under the supervision of people without a special technical education. Therefore, it was necessary to increase the number of technical secondary schools, offering specialized training in mining.

There were only eight such mining schools in the country: three in the Urals with a total of 320 students, and five in Siberia with 482 students. This was a mere drop in the bucket. Besides, it was wrong to have all the schools concentrated in the Urals and Siberia. The mining regions in the South, which played an important part

in economic progress, had no facilities for training technicians of their own. The Congress asked the authorities concerned to reopen mining schools in the Donbas.

Merely opening more schools was not enough; they had to be supplied with modern equipment. Mining colleges had outdated equipment and the funds for replenishment were very limited. Furthermore, teachers conducting practical studies had 40 and more students in each group. This did not make for better training. Only 150 rubles a year was spent on each student and at some colleges as little as 75. The Congress stressed the need for a considerable improvement of educational facilities and the allocation of additional funds.

The Congress also discussed regional distribution of mining colleges. It was decided that the Urals Polytechnic Institute should train mining engineers chiefly for the Urals mines, the Tomsk Polytechnic Institute, for those of Siberia, the Dnepropetrovsk Institute, for those of the Donbas and Krivoi Rog, and so forth. This arrangement was very helpful in providing the major coal fields with qualified engineers and technicians.

The contemplated large-scale mechanization of mining made the training of mechanical engineers for the mining industry an important issue. In my report to the Congress I emphasized the need for special training of mechanical engineers at the Moscow Mining Academy and the Leningrad Mining Institute. The Congress gave much attention to curricula for mining colleges. The Soviet higher educational system was only being shaped at the time, and it was necessary to plan it in detail. There were all kinds of fallacious theories in circulation, going from one extreme to another. Some asserted that only theoretical subjects should be taught, while others maintained the opposite, virtually denying the necessity of a broad theoretical grounding. For that reason, curricula for mining colleges were more than just a topic for academic discussion.

Heated disputes between the advocates of "narrow specialization" and those who maintained that an engineering education ought to cover a wide range of subjects went on day after day. Our Mining Academy was no exception.

In the meantime, it became sufficiently clear that the peculiar features of our mining industry confronted young engineers with a great many problems. Besides doing their immediate job, they had to plan and design new installations and supervise the reconstruction of old mines. All that required sound theoretical knowledge, particularly in such fundamental subjects as physics and mathematics, plus broad engineering training. Unless our mining colleges provided education of this kind, there could be no question of their fulfilling their important mission.

Moreover, beginners did not always have the opportunity to work in their chosen field. The engineers who specialized in coal mining frequently had to work in iron or copper mines. Specialists trained for working native gold had to work alluvial deposits. Experts in the exploitation of oil fields had to drill wells, and so on. This necessitated giving mining students, besides their main subjects, a fairly good grounding in related subjects.

Nowadays, when it is a common thing in the Soviet industries, including mining, for one person to be skilled in several different jobs, when engineers are given a very broad education, the question of widening the so-called boundaries of specialization is too obvious to require discussion. But it should not be forgotten that in 1925-26 the young Soviet colleges and universities were not running smoothly yet, and many issues had to be "fought" for. Small wonder, therefore, that the Congress, which had to resolve so many important and complicated problems of mining, gave careful attention to curricula for mining colleges. The Congress clearly laid it down that young mining engineers must broaden their specializa-

tion if they were to measure up to modern requirements. Hence it decided that students should study related subjects for at least two and a half years, and begin majoring in a narrower field only in the second semester of their third year. It was believed that such an arrangement would induce students to be more circumspect in the choice of speciality. We see now that this was not exactly the right approach, for it inevitably led to a certain uniformity in the training of engineers, which was not always best for the industry.

Many people in those days objected to including political education in the mining student's course, holding that he should concentrate on special subjects only. This view, however, was out of keeping with the social and political system in our country. Sound knowledge of politics and economics was absolutely necessary if mining engineers were to be equal to the big task of building a new life.

The Congress also examined and approved considerable changes in the curricula of mining schools. It decided to make theirs a four-year course, in which particular stress would be laid on laboratory work and practical training in industry.

In addition to specialists directly concerned with mining, the industry was badly in need of economists, statisticians, accountants, calculators and commodity experts. It was proposed that faculties of mining economics should be opened at the specialized schools of industrial economy in Moscow, Kharkov, Baku, and Sverdlovsk and that this subject should be introduced in the third year of the school course. Here, too, great emphasis was laid on practical experience. In addition to their theoretical studies, students of mining economics were to have two three-month periods of practical training in the coal fields.

Among the important matters discussed by the Congress was Professor Shevyakov's interesting report on the improvement of mining techniques in the Donbas. The situation in what was then called "the old Donbas" was

pretty bad. Professor Shevyakov pointed out that the coal reserves in the old Donbas pits were on the whole exhausted, and increasing coal output in the Donbas required the sinking of big mines under a plan extending over several decades. The government was appropriating hundreds of millions of rubles for the purpose, and it was vitally important to work out more expedient methods of mining technology and labour organization and to devise improved mining implements and equipment.

My work often took me to the Donbas and I saw with my own eyes the inadequacy of the techniques employed. Today, the Donbas coal mines are highly mechanized. Most of the mining and transporting is now done by Soviet-made machines and devices. We clearly see our way ahead and know what must be done to advance mechanization in the Donbas. But thirty years ago, when we were taking our first steps, we had to decide what techniques were best suited, and, as we used to say, "to anticipate future methods and implements." That was the essence of Professor Shevyakov's report.

The peculiarities of geological structure and the character of coal beds in a basin greatly affect mining techniques. In drafting the plan for the reconstruction of the Donbas, we took into account the fact that the coal fields were about to get a large amount of electric power from the district power plants then under construction, which would greatly help us in carrying out the mechanization programme. The reconstruction plan envisaged the building of big collieries with an annual output of 700-800 thousand tons and of medium-size mines with an output of 125-250 thousand tons. It was also decided to develop small, shallow pits turning out tens of thousands of tons a year. The idea, however, was soon abandoned because it did not pay. The size of the fields and the working methods were to be adjusted to the depth and capacity of each mine. It was proposed switching to simpler methods of advancing, particularly in the case of longwall meth-

ods. In the Donbas with its thin seams, these methods enabled us to use cutting machines and conveyors to good advantage. The two main methods to be used in the new Donbas mines were the longwall and the long pillar cross-pitch.

The Congress dealt at length with problems of mechanization. Electric chain cutters were considered the most efficient for working flat seams, but we had no such machines. The Soviet engineering industry had not yet got round to making mining machines, and those of foreign make proved utterly unsuitable for the Donbas collieries. Mining coal out of pitching seams was hard to mechanize because you could not very well apply the longwall method and use cutting machines when the angle of the dip was high. So, the thing was to feed compressed air into the dip workings and hew coal with pneumatic hammers, though at that time they needed a good deal of improvement.

There was a heated debate as to what types of haulage were best for the different mining methods. In those days, the most widely used was rail haulage and so the argument centred chiefly on the size of cars. Some claimed that it was best to use large cars; others maintained that in certain instances, particularly when the seam was inclined and the side rock unreliable, large cars were not suitable. The curious thing is that although the advantages of electric locomotives were generally recognized, hardly any were used in the mines prior to the First Five-Year Plan. But to return to the size of the cars. For the next ten years, it was finally decided, the Donbas would use cars with load capacities ranging from 0.75 to 2 tons. This meant that levels would have to be prepared in a different manner.

Another important efficiency problem was that of transporting coal from the stope face to the car. It was decided to use conveyors or scrapers in flat-seam levels, which are predominant in the Donbas. The advantage of the con-

veyor system was not yet clear at the time. Conveyors and scrapers were called "rivals." Roller and shaker conveyors were held to be the most serviceable. Belt or scraper conveyors were to be used only in exceptional cases —when bedrocks were unstable or seams had a dip of more than 3-4°.

As for haulage in the main gangways, there was no agreement on what was better, locomotive or rope haulage. Some believed that electric locomotives were unsuitable because gangways were in constant need of repair owing to the instability of the side rock. The presence of methane in the mines was a deterrent. It was later proved, however, that there were no grounds for these fears, and electric locomotives are now used everywhere.

As far as propping and stoping methods were concerned, it was believed that yielding props, widely used in Germany, were the most practical, and that flushing could be applied in the Donbas only in exceptional cases, say, to prevent ground-sagging under major surface structures. Preference was given to rock-filling, particularly when working spontaneously inflammable pitching seams.

In the case of hoisting methods, the right solution was hit upon immediately. Coal was to be got to the surface in self-discharging skips. Big changes were to be made in the hoisting machinery installed in new mines. The hoists for skips and dump-cages were to have drum winding. It was further planned to use heavy tail ropes in cases where mines were not very deep and the loads not too heavy.

It is only natural that the use of new types of hoisting devices—skips and tipping cages—should require changes in the construction of shaft houses. Small distributing bunkers were to be installed on the surface to receive coal from the skips and cages. From these bunkers coal would go directly to the grading plant. This, it was believed, would make large surface structures unnecessary. This notion, however, was somewhat exaggerated. Neverthe-

less, the idea of reconstructing and simplifying surface structures was correct and timely.

Such were the main trends of mechanization in the Donbas. They might seem very incomplete today, but at that time reorganization of coal production along those lines was a big advance. The many important measures outlined by the First All-Union Mining Congress helped to accomplish a far-reaching programme for renovating the coal industry in the Donbas and elsewhere.

It did not take long to show that under the Soviet system a radical reconstruction of the coal industry, which would have taken decades under the capitalist system, could be achieved in a few years.

RECONSTRUCTION OF THE SOVIET COAL INDUSTRY

In those days, I devoted most of my time to teaching at the Moscow Mining Academy. But although this important job of training young engineers kept me very busy, the upsurge of creative work in all the spheres of life also claimed my attention. Industrialization had just begun, and the urgent task was to reach and exceed the production levels of the leading capitalist countries. Mining, like the other branches of our economy, was making headway. True, this progress was not always rapid enough in the early years, but there was good reason to expect that the pre-revolutionary production peak would be reached and even surpassed.

It is worth recalling how the coal industry expanded and developed in those years. I have several books published at the time, describing the unprecedentedly swift growth of coal production. One of them is entitled *The Fight for Coal*, and the other, *The Donbas in the Battle for Coal*. They bring to mind the events of almost thirty years ago.

The year 1927 was a memorable one. That was when the country's coal output reached the 1912 figure of 36 million tons. In the following year, it went up to 40 million tons and in 1930, to 48 million tons. One of the books stressed that 48 million tons was a tremendous achievement compared with Russia's pre-revolutionary figure, though it was still less than France's output, only a third of Germany's, one-fifth of Britain's and one-tenth of the United States'. Keep these figures in mind, for the ratio of coal production in the U.S.S.R. and capitalist countries kept changing sharply. In 1930, our country was the world's fifth biggest coal producer. Its great potentialities were exemplified by the fast rate at which coal production increased. In 1928 the increase was 8.5 per cent and in 1930, almost 12 per cent. In the five years ending with 1930, annual coal output went up from 17.7 to 48 million tons—an increase of 170 per cent.

This growth was achieved mainly by working old mines. Great difficulties were encountered at every step, and that is a point I would like to dwell on. The famous Shakhty Trial in May 1928 revealed that the saboteurs had used all sorts of wrecking methods in the coal industry, particularly in the Donbas. To understand the difficulties which the coal industry was having at that time, one should know what these methods were. First, the saboteurs resorted to what they called "wet conservation of mines." The mines flooded during the war were left in that condition and various pretexts were advanced not to put them back into operation. The development of local fuel resources—brown coal, peat and shale—was hindered in every way.

When the mine-mechanization programme was launched, the saboteurs turned their attention in that direction. One of their methods, which caused great damage, was to buy foreign machines which were entirely unadaptable to the natural conditions in the Donbas and other Soviet coal fields, and therefore useless. Knowing how indispensable

power was to mechanization, the saboteurs, who had wormed their way into various economic agencies, did everything to retard the building of the Shterovka and Zuyevka plants which were to supply power to the Donbas. Fraudulent planning—deliberate underestimation of capacities, labour productivity, etc.—also did much harm.

Only an insignificant number of the old professional intelligentsia employed in the mining industry were directly or indirectly implicated in acts of sabotage. Most of the old specialists worked honestly and to the best of their ability to restore and develop the mining industry. The word "spetseyedstvo," which literally means "specialist-baiting," can now be found only in some old dictionaries, but in those days it was in vogue because old school intellectuals were often attacked by covert enemies of the Soviet system. The Party, however, put an end to that, and the old specialists joined as equal partners in carrying out the immense task of building socialism. As a matter of fact, we of the "old guard" have been getting a far bigger share of honours and decorations, perhaps not always deservedly, than the younger specialists.

But to return to the late twenties. Thanks to the high rate of growth, the Soviet Union's coal output in 1930 surpassed the 1927 figure by nearly 50 per cent, whereas in Germany it dropped by 7 per cent. There was a similar decline in Britain and the United States. The slump was the forerunner of the crisis which soon gripped the capitalist world.

Meanwhile the Donbas was accelerating production, and the figures cited below give a good idea of the effort made by the miners, and of the attention given by the Party and the Government to the development of the country's leading coal area.

In 1922, when members of the State Commission for Drafting the Rehabilitation Programme, including myself, were inspecting the coal fields, the Donbas was producing

only 7.7 million tons of coal. That was a very small amount, but it was hard to get even that much because many of the collieries were wrecked or flooded, the equipment in the operating mines was almost completely worn out, and there was a shortage of miners. But after 1922, the Donbas began to pick up. In 1923, output rose to 8.1 million tons, in 1925, to 13.4 millions and in 1927, to almost 25 millions.

The restoration of the mines was completed in 1928, and the Donbas entered a new phase of its history. In the following year output rose to 30.7 million tons, exceeding by two million tons the record figure of 1916. This increase was a result of the steps taken under the extensive programme of technical reconstruction. It should be remembered that before the Revolution there were 1,200 coal mines in the Donbas but by far most of them produced no more than 100 tons a day.

Several new collieries, equipped with up-to-date machinery, were built in the Donbas by mid-1931. They were very highly mechanized by the standards of that period. An old newspaper clipping I happen to have saved describes one of these collieries as follows: "It is as clean in the mine as in a watch factory. From the cage landing the chief engineer took us to the pump-station where some men were washing the shiny tile floor. It was hard to believe that this spotlessly clean, high-vaulted room with powerful pumps was hundreds of metres underground. The chief engineer said the station could be shut off hermetically in case of flooding and used to pump out the water.

"From there we went to the power substation which feeds current to the electric locomotives. It was brightly illuminated by thousand-watt lamps. Next we examined the bunkers. Each bin holds 12 tons—enough to fill two skips. The walls of the well-lit gangway were whitewashed, and the trolley line for the electric locomotive stretched snugly under the ceiling. The floor of the gangway was

as smooth as hard wood. It is not in every factory that you will find such cleanliness and order."

This exerpt is rather long, but despite the reporter's amazement and enthusiasm, he gave a fairly accurate description of one of the big Donbas collieries of the day. True, there were not many mines of this kind at that time, but the important thing was that they did exist even then.

The two main factors stimulating mechanization were, firstly, the growing significance of the Donbas as the country's leading coal supplier, and, secondly, the programme for renovating the country's coal industry. When the First Five-Year Plan was launched, the old mines were providing 97.5 per cent of the total coal yield, but by 1933, 56.5 per cent of the coal came from reconstructed and new collieries.

Large-scale construction of new mines was accompanied by an increase in the capacity of the old ones. The growing average output per mine is evidence of the remarkable achievements scored by our coal industry in those years, especially in the Donbas. Before the Revolution (in 1913), annual output per mine in the Donbas averaged 21,000 tons. In 1925, it was 54,000 tons and in 1932, 128,000. Splendid progress indeed. But further development at a faster pace called for a radical technical reconstruction of the coal industry, for a modernized technology.

It was the Donbas which pioneered in mechanizing coal mining. Other coal field followed its lead and, for the most part, applied the same methods. In the early years of the restoration period, which began in 1921, practically all the work was done by hand. As there was a shortage of usable coal-cutters and of men capable of operating them, mechanization was still in embryo.

Between 1922 and 1926, mechanized mining increased from 3.3 to 7.8 per cent. A large number of heavy coal-cutting machines were imported in 1925-26, and from that time on mechanized coal-cutting made real headway. We

had to use foreign machinery because the Soviet engineering industry was not yet producing any mining machines itself.

The next urgent issue was that of hauling coal out of the stope. Scrapers and conveyors were installed in the drifts, and by 1930, 37 per cent of the handling was mechanized. This made for a more effective use of coal-cutters. In the five years between 1925 and 1930, the average efficiency of a coal-cutting machine rose from 11,000 to 18,500 tons a year.

Although these advances were substantial, mechanization was still far from playing a decisive role in the Donbas because it did not extend to all laborious operations and did not interlink the mechanized sections. The turning point came with the launching of the First Five-Year Plan. In 1930, the Government and the Party's Central Committee sent a special commission to the Donbas, where it made a thorough study of conditions in the coal fields and checked on the reconstruction of the old mines and the building of new ones. The conclusion it reached was that mechanization was the best solution for most problems and should therefore be advanced at top speed. The Government and the Party stressed in their decisions the importance of fully mechanizing mining.

Work soon got under way in accordance with these decisions and proceeded very fast. By 1932, notching was mechanized 70.4 per cent as against 41.4 per cent in 1930. The coal fields in the Kuznetsk, Moscow and Karaganda basins, in the Urals and the Far East did not lag behind the Donbas in mechanization and in some cases even outpaced it.

The fast rate of mechanization in the key industries, coal mining included, was due largely to the close and constant attention which the Party and the Government gave to the industrialization programme. By the end of the Second Five-Year Plan the U.S.S.R. was second only to Belgium in mechanized coal-cutting. In our country,

mechanization and coal production developed equally fast, while in other countries the increase in coal output was far slower than the rate of mechanization.

It was quite clear that progress in mechanized mining depended largely on the development of a sound theory concerning the application of machinery in the coal fields. For this reason, and also because we were confronted with the vital problem of manufacturing as good mining machinery as that made abroad if not better, researchers concentrated chiefly on machine-building and on the theories of coal-cutting. Much attention was given to the intricate matters relating to coal-cutting machines and especially their working parts. This was expedited by the introduction of a special course in mining machinery at mining colleges and the establishment of mining machinery chairs. Another important measure was the organization of experimental laboratories and machine designing bureaux concerned with the most essential problems of the mine engineering industry. They were set up in scientific research and state planning institutes. Besides furthering mining-machine research, these measures improved the training of mining engineers. This was all very important, for the Soviet Union was then takling the far-reaching programme of mechanizing coal production on a new technical basis, on the basis of socialist industry.

The Moscow Mining Academy was the first to introduce the new course in coal mining mechanization. That was in 1925. It was the first time the subject had been taught in the U.S.S.R. or abroad, and since there was no experience to go by, the course was far from ambitious at first. But five years later, when mechanization of coal mining in the U.S.S.R. was well under way and sufficient theoretical and practical data had been accumulated, mining machinery chairs were set up at all Soviet mining colleges. By this time, the course I began at the Academy had been so enriched by the research done by my col-

leagues and students that the subject acquired a sound theoretical foundation.

As I have said, foreign countries had started mechanizing coal production in the latter half of the nineteenth century. A good deal of information on the exploitation of mining machinery had been collected, but little had been done to systematize it. Most of the books on mining merely described machines or gave instructions on how to organize work and operate the machines. Books treating of the use of electric power and compressed air in coal mines, and the electric wiring of coal-cutters, were more informative.

When the mechanization programme was launched in the Soviet Union, our scientists made a thorough study of the working parts of coal-cutting machines and the process of coal-cutting in order to provide a theoretical basis for our nascent mine engineering. Researchers and technicians investigated and tested the optimum conditions for the exploitation of coal-cutting machines, and the basic laws of mechanized coal-cutting; they analyzed the performance of cutting chain bars and the required power input, and determined the factors of highest efficiency.

These investigations helped to work out general principles with regard to coal-cutting machines and enabled engineers to design efficient types and models. This trend of research, proceeding from the practical to the theoretical and back to the practical, was characteristic of our approach to mechanization of coal production. It differed from that of mining experts abroad, who approached these problems empirically, that is, from the angle of practical experience alone.

The data accumulated by Soviet scientists and mining engineers were used in the first manual on machinery for mining stratified deposits. I worked on its compilation with M. M. Protodyakonov, a graduate student and son of my old friend and colleague, Professor M. M. Protodyakonov. The manual was published in 1934, and a supple-

ment appeared in 1937. Though the book was far from complete, had certain shortcomings and could not keep pace with developments in Soviet mine engineering, it nevertheless remained the only text-book of its kind used in the higher schools over a fairly long period.

It was while working on the manual that Protodyakonov upheld his thesis, "The Theory of Cutting Coal with Chain-Bar Machines." It was a valuable treatise generalizing all previous research and presenting a theory on coal-cutting. Published later in book form, it was a good contribution to the literature on mining machinery.

The First Five-Year Plan started off the industrialization programme and developed some new, important branches of the national economy, which had not existed in old Russia. The Soviet people won a notable victory by founding the mine engineering industry. Our country gradually cut the import of mining equipment, and was soon able fully to meet its requirements.

The first of the mine engineering plants, built in Gorlovka, manufactured only eleven coal-cutting machines in 1929. But the main thing was that they were Soviet-made. In 1935, the Gorlovka Plant turned out 435 coal-cutters, which was quite enough for our industry at the time. In the same period, the Pnevmatika Plant increased its annual output of pneumatic hammers from 29 to 7,648.

The development of the mine engineering industry in the first and second five-year plan periods made it possible to mechanize coal mining at an increasingly rapid pace. The number of machines and labour-saving devices grew from year to year. In the Donbas the number of cutting-machines, pneumatic hammers and conveyors increased almost 50 per cent, the number of electric locomotives more than doubled, and that of electric drills increased nearly 250 per cent. Many scraper loaders and reloaders, as well as other new machines, appeared in the mines, which became veritable underground factories

equipped with intricate machinery. When the Second Five-Year Plan was launched, the Donbas still held the lead in mechanization, but the other coal fields were mechanized at such a rapid pace that by the end of the period many of them had outstripped the Donbas.

The point at issue was a real technical revolution. And it was not merely a case of substituting machinery for manual labour in certain mining operations, but a matter of introducing all-round face-to-surface mechanization. This, of course, inevitably resulted in the gradual improvement of technology and mining as a whole. The use of coal-cutters and conveyors in working flat seams had no adverse effect on the principle of handling the main operations simultaneously. It opened up tremendous prospects for continuous, smooth and intensive production and for rapid progress.

Towards the end of the first five-year plan period, labour organization in the Donbas mines was revised. A continuous operation method was proposed by some of the leading engineers. Its main feature was that it was rhythmical, all operations being co-ordinated in time. It afforded a number of important advantages in working flat seams. It raised output, ensured a more efficient use of machinery and equipment, sped up the advance of the heading and facilitated roof-control. All this considerably increased labour productivity. The introduction of this method greatly promoted machine efficiency. The monthly output of a cutting-machine rose from 2,650 to 4,450 tons, and the productivity of some machines went as high as 10,000, 12,000 and even 14,000 tons. The miners' labour productivity rose by 10 to 25 per cent.

This paved the way to higher forms of labour organization and gave rise to a widespread innovation movement. But before turning to that, I would like to discuss in greater detail the development of the Donbas, which I have been watching over the last fifty years.

THE DONBAS FROM 1920 TO 1930

In 1921, when I visited the Donbas with the State Commission for Drafting the Rehabilitation Programme, the main problem was how to make the best use of the existing equipment, materials and government allocations to maintain production at least at the level then obtaining, low though it was. The most rational thing, it was decided, would be to concentrate on about 350 of the biggest collieries in more or less good condition.

Most of the smaller pits were operated by various organizations; however, they accounted for a mere 2 or 3 per cent of the total output. Their number gradually diminished, but that had no adverse effect on over-all production, which increased steadily. Despite this general increase, the coal fields remained in a sad state. Financial difficulties, marketing snags and various other factors hampered the restoration of the Donbas.

Things began to improve in 1925, when the rapid development of the national economy greatly increased the demand for Donbas coal. The country's economic conditions improved substantially, and the result was more capital and better equipment for the Donbas. In 1926-27, output exceeded 24.5 million tons. This figure was attained not only by working the existing big and medium mines, but also by sinking new ones. The development of new big collieries, however, was a very slow process, due partly to lack of experience in building them and partly to overt and covert sabotage. Medium and small mines were developed much faster. The latter, called "subsidiary mines" and operated by the Gornoprom Trust, gradually became an important factor in the coal industry.

That trend, of course, could not last long because the main object of the reconstruction programme was to build big collieries. Increasing investments made it possible radically to improve underground equipment, as well as surface structures, steam plants, handling facilities,

railway lines, and so forth. In many operations—among them haulage, sorting, ventilation, hoisting and drainage —steam was replaced by electric power.

This shift necessitated the provision of additional sources of electric power. Several fairly big power plants were built in the coal fields, and a network of substations and transmission lines mushroomed around them. The biggest was the Shterovka Plant, which supplied power to the Krasny Luch and Chistyakovo anthracite areas and to some of the coal fields of the Maryevka area. With more electric power it was possible to accelerate industrial, housing and other construction in the Donbas.

As I have already mentioned, there were many things retarding the sinking of new collieries—inadequate financing, delays in the drafting of projects and the none-too-perfect organization of geological prospecting, etc. Moreover, the building programme was often altered—enlarged, then curtailed, then again expanded, and so on. Nevertheless, the number of new mines kept increasing steadily before and during the first five-year plan period. They were all built with an eye to greater efficiency and productivity, on new technological and economic principles, which differed radically from those of pre-revolutionary days.

At the same time, some of the old mines were thoroughly re-equipped. Their number increased from 17 in 1928 to 25 in 1930. The result was that, in the ten years ending with 1929, the Donbas increased its annual output nearly sixfold—from 4.5 to 30.7 million tons. The 1929 figure surpassed the 1916 record. It is worth noting that this increase was due to the more efficient operation of a smaller number of mines. There were approximately 1,600 Donbas mines in operation in 1916. The number dropped to 954 in 1922 and to 238 in 1925, and then gradually went up to 428 in 1929. The building of big collieries was still going very slowly in 1925, when the demand for Donbas coal began to grow, and that was the reason why so many

medium and small mines were built in those years. They helped to meet the demand for coal, though they were very unprofitable and the quality of coal they produced left much to be desired. That explains why in subsequent years their development was again dropped.

In 1924, more than 65 per cent of the coal came from mines with an annual capacity of up to 100,000 tons. In 1929, these mines accounted for only one-third of the total output. The rest came from mines with a capacity of more than 100,000 tons, especially from the big collieries, which produced from 200,000 to 500,000 tons annually. Such collieries accounted for 31.4 per cent of the total output in 1929 as against 5.5 per cent in 1924.

The drive for more coal stimulated mechanization of underground work, first on a small and later on a large scale. In 1921-22, mechanized cutting accounted for only 3.3 per cent of the entire output, whereas in 1927-29 as much as 40-50 per cent of anthracite and 11-16 per cent of bituminous coal was cut by machines.

The various mining operations were mechanized unequally in those days. Mechanization was far more advanced in coal-cutting than in hauling, most of which was still done by hand or, at best, by horse. There were even sled-tuggers in some of the mines, but they soon disappeared for good. Electric locomotives were first introduced in the mines in 1925, and in the following year they accounted for slightly more than 3 per cent of the haulage. The proportion kept increasing in subsequent years, but very slowly. In 1929-30, only 4.8 per cent of the coal produced was hauled by electric locomotives.

Coal-handling on the surface—transporting, loading and sorting—was mechanized at about the same time as underground. Mechanized loading was developed in two ways. One was merely a more efficient method of replacing manual labour, to which end hoppers were installed on elevated platforms. The other method involved the use of loading machines.

It was obvious, however, that haphazard mechanization could not produce the desired effect and that the whole system of surface arrangements would have to be reorganized. So it was decided that instead of each mine having its own storage, loading and sorting facilities, it would be more expedient to concentrate them at certain mines only, and to have coal from the others transported to these central cleaning plants and loading points. This was called "centrification." In those days of predominantly small and medium mines, this system was something of an improvement, but later its usefulness dwindled, and "centrification" was eventually abandoned. Various surface plants and facilities were established at every big colliery.

As mechanization progressed initial steps were taken to electrify the Donbas and introduce electro-mechanical equipment. Ninety-eight million kilowatt-hours of electric energy were consumed in the Donbas in 1922, 200 million in 1927, and over 600 million in 1929.

An important measure towards building up the required power supply was the hooking of power plants into district distribution circuits. This made it possible to feed electricity to all the mines of a given district uninterruptedly and without resorting to accumulation of big reserves, and also to pro-rate the supply to each consumer in accordance with actual requirements. It also cut maintenance costs a good deal.

By 1930 there were five district power circuits in the Donbas. Power output was raised steadily by increasing the generation load of the stations and installing additional turbogenerators. But despite the comparatively rapid increase of power supply, the Donbas continued to suffer from an acute shortage. The rate of electrification lagged behind the growth of coal production, and in certain years this necessitated an increase in the ratio of steam power. To bridge the gap between power and coal production it became imperative to speed up the building of new power plants. In 1930, construction of big power stations was

pushed ahead at top speed. Among these were the Zuyevka and Kadievka stations and the second and third sections of the Shterovka power plant.

During the early years of the mine reconstruction programme, practically all the Donbas railways were renovated. In 1924, there were 152 kilometres of narrow-gauge track and 788 kilometres of wide-gauge track. Old rails were gradually replaced with new ones and the narrow-gauge lines were widened to standard. In 1928, the length of wide-gauge track reached 1,000 kilometres. Old locomotives were replaced with new ones, but not so fast as could be desired. In 1930, there were still 64 locomotives aged over 30 years.

Big changes were also made during that period in coal preparation and coking. The question of improving preparation (cleaning and sorting) became pressing in 1924-25, when there were temporary marketing delays. Fines and discounts were instituted for low-grade coal, and this compelled miners to turn their attention to improving quality.

Old preparation plants were swiftly restored and considerably expanded, and some new ones built. This increased the amount of coal cleaned and graded. Nevertheless, 50 per cent of the sorting was still done by hand and technically the whole preparation process was still below modern standards.

Another matter made urgent by the rapid growth of the steel industry in the South was the development of coking. Most of the coke-ovens had been partially or completely destroyed during the Civil War, and it was a very hard job to restore them. It was decided to do the coking only at the best and biggest plants. Outdated ovens were removed and new ones installed. These were able to recover and utilize all the by-products of the coking process. Further improvements in the technology of coking necessitated the building of new big plants, and several of them were set up at that time.

THE DONBAS ON THE EVE OF THE WAR

The five-year plans turned the Donbas into the country's leading coal area. By 1940 it was producing almost four times as much coal as in 1913. In nearly all of the bituminous and anthracite areas new big collieries with a daily output of 4,000-4,500 tons were built, and in most of the old mines production was raised to 1,000-1,500 tons daily. There were only a small number of mines producing at the rate of 500 tons or less, and these were the old ones.

On the eve of the Great Patriotic War, the Donbas was already highly mechanized. Machines and mechanical devices handled 95 per cent of coal-cutting, 77 per cent of haulage and 89 per cent of loading into railway cars.

I visited the district several times in those years, and saw the great changes that had taken place in the technology of coal mining. Usually, a coal seam was approached from the surface through two vertical shafts about five metres in diameter. Sometimes they were only 40 metres apart and sometimes 600. When they struck the coal bed, the two shafts were connected with a cross-heading. Thus each mine had two outlets. One was used for hoisting coal and running the piping, and the other served as the upcast through which return air, sucked in by ventilators from the underground drifts, was brought to the surface. The average depth of a shaft to the first underground level ranged from 200 to 300 metres. The deepest shaft in those days was that of the Kochegarka Mine in Gorlovka. It was originally sunk in 1868 and eventually deepened to 750 metres. At other mines the shafts were much shallower.

The same cars which brought coal from the working faces were placed in cages and raised to the surface. Sometimes coal was dumped from the cars into shaft-siding bunkers, and from there it was mechanically heaped into skips. The skips, hoisted with great speed, were emptied on the surface by mechanical tilters.

Flat seams were worked chiefly by coal-cutting machines, inferior, of course, to the types now used. Electric coal-cutters had chain bars up to 2 metres long. The toothed chain would undercut the seam to a depth of about 1.8 metres. The block of coal hanging over the slit was then shot down with explosives. The blasted coal was then shovelled on to a shaking or scraper conveyor which carried it to the track of the main lateral gangway, where it was loaded into cars and hauled to the hoisting shaft by an electric locomotive.

That, in general outline, was how coal was mined and transported in the Donbas on the eve of the war. The technology was not so good but it was a great improvement on the old technology and at that period it was evidence of a pretty high standard of mechanization and efficiency.

The Donbas pioneered in the field of mechanization after the Revolution. It was the first of our coal fields to switch from the old mining methods based on muscle power to mechanized methods. Other coal fields followed suit. The Donbas thus played an important revolutionary role as initiator of technical progress in the mining industry, and showed other coal fields how to raise productivity through mechanization. It ushered in the great industrial innovation movement which paved the way to better labour organization and greater efficiency.

On August 31, 1935, Alexei Stakhanov hewed 102 tons of coal with a pneumatic hammer in the course of a shift, whereas the production quota was only six tons. It was the beginning of a new stage in labour organization—not only in the coal industry but in the national economy as a whole. I remember the tremendous interest with which mining experts read newspaper reports on the achievements of innovators. It seemed that Stakhanov's record was hard to eclipse, but soon other miners were producing as much as 500 and 600 tons per shift. One of them, Puzanov, raised the record to 705 tons, or a trainload of 40 cars.

Such achievements no longer amaze anyone, for labour productivity has grown much higher since then. But at that time, I must own, mining scientists and engineers were perplexed. We thought we had mastered all the subtleties of mining and all the methods of raising labour productivity, but the achievements of the innovators upset our notions about the limits of a miner's efficiency. Some of us claimed that these were chance achievements. It did not take us long to see, however, that the old production standards were being fast outstripped not only by individual miners, but also by whole crews, shifts and collieries. Those who had advocated "ceiling quotas" were compelled to admit that the new movement was something more than an effort by individuals to attain outstanding records, that it was a transition to a higher stage of socialist organization of labour, a movement of the rank-and-file workers to devise new methods for raising labour efficiency to an unprecedented high.

The innovators' movement marked the beginning of revolutionary changes in many spheres of mining. It compelled us to revise many deep-rooted concepts on the nature of mining operations and to approach the key problems of technological progress from a new angle.

Before the war, Soviet industry produced diverse types of mining machinery in increasing quantities, and the technical equipment of the collieries kept improving from month to month. On the eve of the war the Donbas coal fields had 640 winding plants with an aggregate power of 100,000 kilowatts, 570 ventilators with a suction capacity of 760,000 cubic metres per minute, and 2,630 pumps with a total delivery of 210,000 cubic metres of water per hour; down in the mines there were 1,400 electric locomotives and more than 125,000 cars. The most extensively mechanized operation was that of getting the coal; about 3,000 coal-cutters and over 10,000 pneumatic hammers were used. The handling of coal on the surface was highly mechanized too. Complex machines and other

mechanical devices were used for transporting, cleaning, grading and loading coal into railway cars.

The technical revolution began in the Donbas with the launching of the First Five-Year Plan of industrialization was almost completed when the war broke out. The collieries—veritable "underground factories"—kept raising output from month to month, and it is safe to say that, were it not for the fascist invasion, the Donbas would have reached the present volume of production in the early forties. But the war precluded that.

Before turning to the period of the Great Patriotic War, which the Soviet people always recall with a feeling of bitterness and wrath, I would like briefly to describe the pre-war changes in the training of coal mining engineers and technicians.

ADVANCES IN MINING EDUCATION

The rapid growth of the mining industry called for improvements in the training of specialists and the establishment of additional chairs and faculties.

Hundreds of new mines, concentration plants, metallurgical works and metal-working factories for processing non-ferrous, noble and rare metals, as well as metal scrap, were being built all over the country. This necessitated the institution of an independent faculty offering instruction in non-ferrous metals, and the training of more specialists in alluvial ores. Such a faculty was opened at the Moscow Mining Academy in 1929. It trained engineers in five specialities.

Every improvement and extension of our Academy was welcomed enthusiastically by our teaching staff. The absence of a big lecture-room hampered normal studies for a long time because certain review lectures, which should have been delivered to a large audience, had to be delivered separately to various groups. When we finally

obtained a spacious lecture-room, we marked the event with a celebration. We celebrated again when we acquired a badly-needed laboratory for practical chemistry. Later such pleasant occasions became so frequent that we would celebrate several at a time.

Research gradually gained importance in the general educational process. There was great need for closer contact between the higher educational institutions and the industries and for more assistance to miners on the part of scientists.

It was a red-letter day when our teaching staff was entrusted with preliminary research and prospecting in the area of the Kursk Magnetic Anomaly, and of drawing up technical plans for the development of its iron deposits. The task was assigned to a large group of specialists headed by Academicians I. M. Gubkin, P. P. Lazarev and A. D. Arkhangelsky. Three of our teachers—S. D. Osnovin, A. S. Popov and M. M. Fyodorov—worked on mining problems. N. P. Chizhevsky, V. I. Trushlevich and several others concerned themselves with ore-dressing projects. Later, at a general meeting to mark the fulfilment of the assignment, it was pointed out that many of the research problems solved by college teachers were of great practical and theoretical value.

M. I. Kalinin visited the Academy several times in those years and he always gave us invaluable advice on professional training and political education. The Academy had by then become one of the country's largest higher technical schools. It had 22 well-equipped laboratories, 25 demonstration-rooms and a library of 62,500 volumes (Russian and foreign scientific books and journals). In the early thirties, when the Academy had graduated 450 engineers, it had a highly competent teaching staff—15 professors, 30 docents and 200 assistant professors.

The Academy established close contacts with the coal, oil and ore mining industries. Besides research in the Kursk Magnetic Anomaly, the Academy's scientists carried

out other important assignments, one of them prospecting for oil for the Azneft, Grozneft, and other trusts. Moreover, the Academy compiled and published text-books and manuals which proved very helpful to both the students and the teachers of mining schools in Moscow and other cities. Much was done to improve teaching methods and educational processes, with the result that our graduates received better training.

All this made it possible to split the Academy into several independent institutes specializing in different branches of mining. The need for mining engineers had by then increased so much that one higher educational establishment was utterly inadequate to cope with the problem. In May 1930—a memorable month in the history of the Soviet mining school—the Supreme Council of National Economy of the U.S.S.R. issued an order to transform the Moscow Mining Academy into six independent industrial institutes. The new colleges which grew out of the Academy's faculties were: the Mining Institute, the Institute of Ferrous Metallurgy (now the Steel Institute), the Institute of Non-Ferrous Metals and Gold, the Oil Institute, the Institute of Geological Prospecting and the Peat Institute.

The main reason for this reorganization was the need to enrol a far greater number of students. The first thing was to find additional premises. Two storeys were added to the buildings assigned to the Mining, the Oil and the Steel institutes. The Mining Institute received a new building for its physical, chemical and other laboratories. New buildings were erected for the Institute of Non-Ferrous Metals and Gold and for the Peat Institute.

The shortage of premises made things rather difficult for the new institutes during the first few years, especially for the Peat Institute which had no building of its own and had to begin from scratch. The "pains of growth" did not last long. The Peat Institute soon came into possession of a half-ruined building in Bolshaya Ordynka

Street, and adapted it to its purposes. At the same time it began putting up a new building in Bolshoi Vuzovsky Street.

The other institutes soon got to their feet too. During its first year, the Institute of Non-Ferrous Metals and Gold occupied the third floor of the old Mining Academy building, while a new building was being put up. The Institute moved in when it was completed and has remained there to this day. Another two buildings were added later.

The Mining Institute got off best because it remained where it was and had none of the house-building troubles, although it is still cramped for space.

When the Mining Institute was established as an independent college it had only four laboratories and six cabinets, but within three or four years the number of well-equipped laboratories increased to 18 and of cabinets, to 24. This was done with a dual purpose: to improve training and to expand facilities for more serious research. Having obtained modern equipment, the Mining Institute was able to concentrate on a series of research problems important to the coal industry.

Another matter that claimed attention was the expansion of the Institute library. Within a few years the number of books and journals on mining subjects exceeded 300,000. The libraries of the other new institutes had smaller but equally impressive collections. All in all, these institutes had 546,000 books and periodicals as compared to the Academy's 70,000 in 1929.

The technical revolution in all branches of industry, including mining, increased mechanization and the introduction of new techniques faced the mining colleges with the necessity of better training, and of broadening the range of mining engineers' qualifications. This imposed a greater responsibility on the teachers. When the Mining Institute was merely a faculty of the Academy, it trained engineers only in three major fields. Now it began to give instruction in ten special fields. The other institutes

likewise enlarged their range. Three of them—Oil, Non-Ferrous Metals and Gold and Peat—readjusted their training programmes so as to turn out engineers in nearly twenty specialities. This was gratifying, of course, for it showed that the Soviet mining school was on the upgrade and coping successfully with its new tasks. Further evidence of this was a substantial increase in the number of students. The student body of the old Mining Academy never exceeded 1,000, whereas now the new institutes had a total enrolment of about 6,000. The Mining Institute alone had almost 900 students.

Veteran educators who were well familiar with the system of mining education in tsarist Russia, when students were counted not in thousands but in hundreds, were particularly delighted to see mining education thrive so well under the socialist system. We were proud that our country's rapidly growing coal industry no longer suffered from a shortage of engineers, and that the latter were dealing effectively with the problems that cropped up.

Besides the basic faculties, the Moscow Mining Institute had a preparatory division which admitted secondary-school graduates. That was a very helpful arrangement and it is a pity we no longer have it.

In order to teach such a large number of students in so many special subjects, our teaching staff naturally had to be enlarged. I have mentioned above that the faculty of the Mining Academy had drawn on the finest teaching talent. Our Institute continued that tradition. The quality of training kept improving from year to year and, judging from the hundreds of letters we received from all over the country, our graduates were doing splendidly. Personally, I have come across engineers graduated by the Mining Academy and the Moscow Mining Institute in the Donbas, the Karaganda and the northern coal fields, and I dare say they could be found in every mining district of the Soviet Union.

But to return to the Institute. Faced with the need to train engineers in new specialities, the teachers had to put in much work to improve educational methods and processes. New curricula had to be drawn up, and this required new text-books and manuals. The professors and teachers of our Institute had always given very close attention to the compilation of text-books designed to improve professional training in line with the directives of the Party and the Government.

It has now become an established tradition at the Moscow Mining Institute closely to combine theoretical instruction and practical experience and constantly to strengthen the Institute's contacts with the mining industry. Throughout the term of their studies, the students were linked to mining enterprises in one way or another. Every student had to go through three periods of practical training in the mines. On the other hand, mining experts from the coal fields came to the Institute to give individual and group advice to students, and teachers too. Besides, professors and teachers sometimes spent long periods in the coal fields, where they helped to plan new collieries and to reconstruct old ones, and sat on commissions assessing mining projects, mine exploitation and construction work.

Such forms of contact with the industry (now a common element of the manifold educational functions of every technical college) were widely practised before the war. In this manner the professors and teachers of the various engineering colleges in Moscow contributed to the common cause of building socialism in our country. Before the war, the teachers of our Institute helped various mining enterprises no less than they do now to solve their problems. Their work proved very fruitful.

The old Mining Academy, as I have said, maintained close contacts with the coal industry and carried out various research assignments. After the split-up of the Academy, the new institutes greatly enlarged their

research staffs, and as more laboratories were built and equipped co-operation between science and industry expanded.

In the years preceding the war, our research was not confined to mining alone; we also worked on diverse problems of our country's development. Among other things, our scientific workers took part in the reconstruction of Moscow, launched at that time. Many of them worked on intricate technical problems connected with the building of the Moscow Metro (Undergroud), of which our capital is justly proud.

I was then a member of the Government Committees taking over from the builders the completed first and second sections of the Metro (built before the war), and examining and endorsing plans for the third section, and I saw how much attention was given to this project by the Party and the Government.

The Metro builders did a brilliant engineering job. I knew that they had to solve difficult technical problems. One of the most serious was to find ways of coping with quick ground, which at one time threatened to bring construction to a halt. Effective methods had to be found to freeze it and better types of reinforcement had to be devised for the underground workings. Mining experts were of great help to the Metro builders in solving these and many other problems.

When the first line of the Metro was finished and the delighted Muscovites saw how beautiful the stations were, they realized what a great thing mining engineers, builders, architects and sculptors had accomplished. Perhaps some of the stations were not so magnificent as those built since the war, but at that time they were certainly splendid models of architecture and engineering. The Government Committee that commissioned the first and second sections noted with satisfaction the high quality of the construction, engineering and installation work. Time has proved the correctness of their appraisal. To this day the first sections

of the Moscow Metro continue to give excellent service to multitudes of passengers.

The building of the Metro was not the only job of Moscow's reconstruction programme with which I was connected, for I was then chairman of the U.S.S.R. Academy of Sciences Committee for Promoting the Reconstruction of Moscow. In that capacity I was directly concerned with major reconstruction problems and had detailed, first-hand knowledge of the immense scale of the programme which was carried out in an amazingly short time.

Muscovites are accustomed to the speed with which their wonderful capital is changing its appearance. Each year new apartment houses, totalling hundreds of thousands of square metres of floor space, rise in new, well-planned streets and avenues. Soviet scientists have contributed much to the success of this enormous enterprise.

The institutions of the U.S.S.R. Academy of Sciences played a big part in the realization of the First General Plan for the Reconstruction of Moscow. It called for the erection of new buildings, the shifting of old ones to new sites (this was widely practised before the war), and the relaying of underground pipes and cables. These were among the serious problems that required the assistance of research workers, who eagerly responded to the government's call to help the builders.

The work done by the Academy of Sciences Committee for Promoting the Reconstruction of Moscow revealed once again the great advantages of close collaboration between scientists and the men who put scientific knowledge to practical use. The scientists helped the builders and the latter, in their turn, helped the scientists to put their theoretical calculations to a practical test and to gain a better idea of the cardinal problems awaiting solution.

While I am at the period preceding the Great Patriotic War, I would like to return once more to my work at the Mining Institute.

Here is what I wrote at that time in the newspaper *Gornyak na Uchobe* (*The Miner Student*): "The practical aspects of socialism are becoming more complex. They require more rapid progress on our part, deeper penetration into the essence of our science, and better management of the complex production operations. This means that we must learn to apply Marxist-Leninist methodology to our concrete scientific subjects, to stop being the empiricists we sometimes are, and to become scientists who think dialectically."

In another issue of the same paper I wrote in 1939 that "it is vastly important for us teachers of a new generation of engineers, to comprehend Marxism-Leninism. One of the distinct features of our educational system is that students must master not only a certain profession, but Marxism-Leninism as well....

"I am convinced that professional knowledge alone, no matter how extensive, is insufficient for a teacher of a technical college. A college instructor must be capable of scientifically generalizing industrial data, thinking as an analyst and foreseeing the trend of scientific development in his own sphere; he must be able to instil a materialistic philosophy in his pupils."

It was no easy matter for me, a man of 65, to pore like a student over the classics of Marxism-Leninism. I must confess that as a person accustomed to dealing with technical matters only, I found it hard to fathom abstruse philosophical conceptions, and, besides, I had not enough time. Nevertheless, I began to study the fundamentals of Marxism-Leninism independently. Realizing that my knowledge was insufficient, I decided to enter the University of Marxism-Leninism, and did so in the autumn of 1939.

I delivered two lectures at the University. One was on the interdependence of natural science and dialectical materialism, and the other treated of formal logic and dialectics. I must admit that I was as nervous reading these

papers as when I had delivered my first public lecture many years earlier. But it seems that I did not do so badly.

My grasp of the laws of materialistic dialectics helped me to find a scientific explanation for that most significant and sweeping movement of the time—industrial emulation. I shall not conceal the fact that when I heard of the first achievements of our innovators, I did not immediately see the historic roots of the movement or realize the great possibilities inherent in it. But it was only logical that this movement should have started at the very time when socialism was emerging victorious in our country. It stemmed from the workers' higher standard of living, from the absence of exploitation in our country, from the introduction of new technology and machinery, and from the appearance on the scene of men and women eminently capable of operating the new machinery. That is why the movement, which originated in the Donbas, spread swiftly throughout the country and involved not only the coal industry, but all the other branches of the national economy.

Equally logical were the changes in the techniques and organization of work arising from the new production standards achieved by the innovators. In the coal industry, the changes were substantial: stope faces and benches were lengthened, labour division was introduced in certain operations, a more progressive system of labour organization, the "continuous cycle," was adopted and new types of machinery and equipment were put to use. All these technological changes, closely linked with the development of the innovation movement, paved the way to further improvement of working methods.

In socialist society, the gigantic practical projects embodied in our five-year plans broaden the horizons of scientific concept and stimulate rapid scientific progress. The broadness of scientific concept blends with revolutionary practice. A striking example is the realization of the idea of gasifying coal underground. Before the Revolution, Mendeleyev and, after him, other Russian scientists raised

the question of utilizing coal by this progressive method, without bringing it to the surface. But Lenin pointed out that if this idea, designed to improve the working conditions of the miners and spare them the harmful effects of smoke, dust and filth, were to be realized under capitalism, it would "inevitably breed mass unemployment, large-scale impoverishment, and deterioration of the workers' condition."

Time has borne out these words. Only under socialism did it become possible to experiment in underground gasification of coal along genuinely scientific lines, and such gas stations were built at some of the mines before the war. Only under the socialist system can scientific and engineering achievements be actually placed at the service of the people, of society as a whole.

This, again, is logical because socialism ensures maximum technical development, makes it possible swiftly to turn every new discovery or invention to advantage, and continuously stimulates the improvement of industrial techniques.

Science is becoming an increasingly important weapon in the popular drive for technical progress. This drive is successful because beyond the narrow practical affairs of the moment we can see vast prospects of development. Such perspicacity comes with the comprehension of Marxism-Leninism.

THE WAR YEARS

When the war broke out every Soviet citizen had to decide what contribution he could make to the common effort. I was past the age when I could fight at the front, but from the first I considered myself mobilized, and dedicated all my energy and knowledge to the great cause of winning the war.

A meeting of Moscow scientists, a few days after the outbreak of the war, brought into focus the enormous tasks

facing us in using the country's natural and other resources. It was the duty of every scientist to make the utmost effort in his own theoretical field towards the enemy's defeat. Ours was a very important, honourable and difficult mission, and we all realized the great responsibility resting with Soviet scientists.

The government decided to evacuate the U.S.S.R. Academy of Sciences and its main research institutions from Moscow to Kazan and Sverdlovsk in order to enable scientists to carry on with their work unimpeded. In Sverdlovsk, the largest industrial and cultural centre in the Urals, we saw brightly-lit streets for the first time after several months of black-out in Moscow. We saw the huge buildings of the new industrial plants, such as the Uralmash (Urals Machine-Building Works), and the old, time-blackened buildings of the Verkh-Iset Iron and Steel Plant, founded over 200 years ago in Yekaterinburg, as Sverdlovsk was then called.

I remembered Yekaterinburg, the heart of the Urals mining industry, as it used to be in the old days, and had watched that city of old legends flourish. By 1941 the five-year plans had turned Sverdlovsk into a real modern city. Its main thoroughfare, Lenin Street, runs several kilometres, connecting the Verkh-Iset Plant with Vtuzgorodok, the city's scientific and educational district. The housing estate that has sprung up in the neighbourhood of the giant Uralmash Works is a splendid new town by itself with tall buildings, straight avenues and a wonderful workers' club.

The Academy of Sciences already had a branch in Sverdlovsk comprising several large research institutions, among them the Institute of Mining and Geology. The scientists who came from Moscow, Leningrad and Kiev and their Urals colleagues collaborated in turning the area's inexhaustible mineral resources to defence needs.

There were many difficulties: shortage of housing, laboratory equipment and research personnel, for quite a num-

ber of scientific workers had joined the Army. But all that notwithstanding, the scientists fulfilled the tasks set to the Academy of Sciences by the State Defence Committee.

In those grim days I suffered a grievous loss: two months after the outbreak of the war my son was tortured to death by the fascists in Kiev.

News from the front was not comforting in the early months of the war. I remember how, on our way to work, we would join the crowds around the loud-speakers in the streets and listen to Soviet Information Bureau communiqués. We put our hearts into our work, for, though we realized that it was much harder for those at the front, we were aware that our own work was just as important as the exploit of a soldier, and that solving the problem of harnessing the natural resources of the Urals and the eastern regions was tantamount to a major military victory.

The U.S.S.R. Academy of Sciences held a session in 1942 in the Sverdlovsk Officers' Club. Attending were the country's most eminent scientists. The remarkable thing was that they also discussed problems bearing on the future. Battles were raging along a thousand-kilometre front; the enemy was ravaging the Ukraine, Byelorussia and the Baltic republics, but here in the Urals scientists were already considering rehabilitation of those areas. It was decided to draw up a well-grounded restoration programme, and the scientists set about it with confidence in their country's might and the inevitable defeat of the enemy, a confidence typical of the Soviet people as a whole.

The Nazis had done enormous damage in the Donbas, though the actual extent became known only after they had been thrown out. But I was certain that it would not take long before the Donbas was again the country's leading coal producer. Far away in the Urals, plans were already being made for the restoration of the coal fields.

The Academy's session revealed that Soviet scientists had done a great deal in the central and eastern parts of the country, and that they were giving much valuable prac-

tical aid to the war industries and the front. Exploration of natural resources was going apace. New large deposits of minerals were prospected in the Urals and the eastern regions, and mining was so well organized that the output of coal, ore and other minerals went up more than tenfold.

It is worthy of note that, besides helping a great deal in developing the country's natural resources and increasing the output of tanks, aircraft, tommy-guns and other badly needed war supplies, scientists continued with their theoretical investigations as in peace-time in spite of all hardships. There was no let-up in progress throughout the war, and this was an indication of the tremendous vitality of the Soviet system. The achievements of the Academy's institutions in Sverdlovsk during the war years showed that Soviet science really serves people.

Eventually news from the front became more cheering and heartening. The fascist drive on Moscow was repelled. The blockade of Leningrad was smashed. The enemy was routed at Stalingrad.

Many of the Academy's institutions returned to the capital early in 1943. I returned too. In Moscow, I learned of the valuable contribution to the war effort made by the Moscow Mining Institute, which had been evacuated to Karaganda. They had conducted a series of studies and surveys directly concerned with defence requirements and industrial development. One of the jobs I would like to mention was that done by a committee headed by Academician A. A. Skochinsky. Its extensive investigations were aimed at finding additional reserves of coking coal in the Kuznetsk and Karaganda basins, exploiting the reserves more efficiently, increasing the capacities of operating mines, and improving labour organization.

Upon our return to Moscow, Professor N. M. Pokrovsky and I were put in charge of a group of teachers of the Moscow Mining Institute who collaborated with the Bureau commissioned to draw up an over-all plan for the res-

toration of the Donbas. Scientists also took part in the work of another special committee set up at the time to deal with problems of rehabilitation of the Donbas coal fields. Though only a part of the Donbas had been freed from the enemy, plans were already being made in Moscow to revive the country's leading coal basin and provide for its further development.

POST-WAR REHABILITATION OF THE DONBAS

On April 28, 1944, I delivered a public lecture at the Hall of Columns of the House of Trade Unions on the reconstruction of the Donbas. It would seem that the Muscovites had more important things than lectures to think about at that time, but the people in charge of the Lecture Bureau of the Committee on Higher Education, who had asked me to deliver the lecture, said the subject roused great interest and many would like to know what was being done to put the Donbas back on its feet. I was glad to hear that, for it meant that the Soviet people regarded the restoration of the Donbas as one of the most urgent problems, and that even though the war was still raging, they were already looking ahead and thinking of the future. Needless to say, I eagerly accepted the invitation.

The question on my mind was how to treat the subject. Should I outline the development of the Donbas since prerevolutionary times, describe how it was mechanized and expanded under the five-year plans and what condition it was in prior to Nazi occupation? Yes, I would have to touch on all those questions, but they were not the chief points. The main thing, I thought, was to familiarize the audience with the basic technical problems involved in rehabilitation, explain what was already being done in the mines singled out for immediate restoration, and describe the basic trends of technology in the reconstruction of the coal fields.

The attention with which the audience listened to the lecture convinced me that I had chosen the right method of handling it. They showed particular interest in the description of the large-scale restoration programme and of the work that had already been started to repair the damage done by the Nazis.

The words with which I concluded my lecture were regarded by some as too optimistic, although they merely reflected the actual state of affairs. This is what I said:

"The restoration of the Donbas will require Herculean effort, skill, ingenuity and initiative because it is a difficult job, and because we lack machinery, materials, electric power and manpower. But if we work hard, we shall achieve the pre-war output level within two and a half or three years. The firm will of Soviet miners and of our entire people will undoubtedly raise the Donbas from ruin, and we shall see it grow stronger and more majestic than ever. It will regain its reputation of 'the Soviet Union's stokehold' and will again be a leading source of fuel and power."

Time has proved that my hopes were not too optimistic. Thanks to the enthusiastic effort of the Donbas miners, the support they got from the nation and the state, the enormous task was carried out very swiftly.

I was directly associated with the drafting of the Donbas rehabilitation programme and with rehabilitation work in general, and I must say that in my 50-odd-year career as a mining engineer, I had never seen such an extremely difficult engineering project carried out so well and with such dispatch. The post-war revival of the Donbas once again revealed the immense creative potential of the Soviet social system, and showed what great advances Soviet science and engineering had made before and during the war.

The Donbas was highly developed, well equipped and far advanced in production methods even before the war. It accounted for approximately 57 per cent of the Soviet

Union's total coal output. As far as mechanization was concerned, it was among the foremost coal fields of the world.

A large number of big mechanized collieries had been built in the Donbas under the pre-war five-year plans. On the eve of the war there were some 350 basic collieries in operation and about 2,000 smaller mines. The average output of a major colliery was 850 tons a day. The total daily production of the whole basin was 250,000 tons.

The number of workers employed in the basin's coal industry before the war was 400,000, while the total population of the coal areas, connected in one way or another with the industry, was in the neighbourhood of 1,200,000.

At the time of the Nazi invasion of the Donbas, there were another 72 collieries under construction with an estimated total output of 100,000 tons a day.

Such was the scale of industrial development in the Donbas. Had it not been for the war, it would have grown to much greater proportions.

Retreating under the blows of the Soviet Army, the fascist troops wrought havoc in the Donbas. Incidentally, the fascists had counted on getting big supplies of coal from the Donbas, but their attempts to exploit the mines failed miserably. Throughout the period of occupation, the Germans got practically nothing out of it. The most they were able to do was to mine small quantities of low-grade coal from the shallow pits they themselves had dug and primitively equipped. Because of the resistance of the Soviet people, they not only did not get any Donbas coal to Germany, but had to bring coal to the Ukraine from Germany and Poland.

Flying from the Donbas, the Nazis almost completely destroyed its coal industry. They set fire to some mines and flooded others, demolished factories, and reduced flourishing mining towns and settlements to ruins.

The damage was enormous. You can judge of its extent from the report of the Extraordinary State Commission

for Investigating the Crimes of the German Fascist Invaders on the situation in the Stalino Region, where the coal fields were operated by the Stalinugol Coal Mining Administration. In this region alone the invaders wrecked 140 collieries; only 12 shallow pits with a combined daily output of 500 tons remained intact. They blew up 154 shafts exceeding 15 kilometres in length and some 200 headframes. A headframe is the main structure of steel or reinforced concrete towering 18 to 45 metres above the mouth of a shaft and serves as a support for the guide-pulleys that hold the cables running from the winding machines down to the cages or skips at the pit bottom.

The fascists also destroyed 292 winding machines of the Stalinugol mines, blew up or burned 241 of the 268 surface plants and buildings with a volume of 385,000 cubic metres, and wrecked 266 engine-houses with a volume of more than one-quarter of a million cubic metres. They razed to the ground 1,227,000 square metres of floor space in the settlements of the Stalinugol Coal Mining Administration.

They also destroyed the mines, plants and settlements of the Voroshilovgradugol and Rostovugol coal mining administrations. It is hard to picture the magnitude of the job that had to be done to rebuild the Donbas and restore its reputation of the Soviet Union's stokehold.

The fascists had hoped to put the Donbas out of action for many years to come. The aim was not only to destroy the various mine structures, but also to flood the mines, and they worked out the methods of destruction accordingly. Demolition experts worked out the procedure for blowing up the shafts, headframes, ventilators, surface plants, etc. But in a coal area as far-flung as the Donbas it was not an easy matter to destroy all the mines and structures, for that required much time, labour and material. The invaders were short of all that, especially of time, for they had to get out of the Donbas post-haste. They therefore resorted to the same methods by which they had wrecked

French mines. Before blasting the shaft pits, demolition teams crammed the shafts with whole trains of cars and locomotives, cages and other bulky objects. The head-frames were dynamited in such a way that they fell on the engine-houses and since they weigh between 100 and 140 tons each, they easily crushed the engine-houses and the hoisting machinery.

Different methods were used for destroying winding machines, ventilators and boilers. Charges of explosives, placed inside the machines, blasted them to smithereens. Smoke-stacks were blown up from one side, crashing of their own weight. The Nazis also managed to take some of the machinery to Germany.

Many of the mines were dynamited and flooded. By the time the fascists had been driven out, the mines were more like enormous underground lakes, with a volume of water estimated at upwards of 300 million cubic metres. Some mines contained as much as 10, 15 and even 25 million cubic metres of water. Wherever the underground equipment had not been destroyed, it was submerged and placed beyond reach. Most of it had become unusable anyway. When the flooded mines were investigated, it was found that about 50 per cent of the steel and 70 per cent of the wooden shaft-reinforcement was entirely destroyed or damaged. From 70 to 80 per cent (in volume) of all the surface plants and structures lay in ruins.

Such, according to incomplete data, was the picture of devastation wrought in the Donbas by the German fascists.

In tackling the problem of reconstructing the crippled and flooded mines, we were confronted with the choice of engineering methods, for it was on them that the effectiveness and speed with which the task could be accomplished depended. The first thing, therefore, was to decide beforehand what was to be done and how the several hundred coal mines could be restored in the shortest time possible and with the least expenditure of labour and materials.

The workers of the coal industry, assisted by scientists,

coped brilliantly with the task, and solved all the technical problems that cropped up in the course of reconstruction. The revival of the Donbas in record time again attested to the high standard of mining science and technology in our country.

Within a year and a half after the Germans had been driven out, there were over a hundred mines back in operation and several million square metres of housing space rebuilt, and that certainly was a noteworthy achievement. The Donbas was again supplying the country with its excellent coal. By mid-1945, when the war ended, the mines were producing tens of thousands of tons of coal daily. A large percentage of it was coking coal. That was a great victory indeed, considering the shortage of equipment, materials and manpower.

How was it that the Soviet people succeeded in making such marvellous progress, inconceivable in any capitalist country?

In rehabilitating the Donbas and restoring the mining industry, we equipped the mines with up-to-date machinery, and built new basic collieries.

The toughest job was that of getting the underground workings back into operation. The drifts and passages in some of the collieries stretched for tens of kilometres. The retreating fascists, hard pressed by the Soviet Army, destroyed first of all the mine outlets, the pits of the vertical shafts. This left the surface pitted with craters four to ten metres deep and eight to twelve metres wide. In some cases they were 40 metres deep, engulfing both the headframes and the shaft-houses.

Besides wrecking the shafts, the fascists destroyed the pit bottoms in which most of the basic underground equipment is concentrated. The pit bottom is an enlarged section at the junction of the first horizontal level and the vertical shaft, and is a kind of regulating centre of the mining operations. It usually contains the headers, drainage pumps, central underground electric station, rescue

equipment, mechanical equipment for handling the coal, etc. Reopening the pit bottom was a particularly hard job and took a lot of trouble and effort.

Sometimes the only solution was to fill up the old shaft with rock and dirt and then sink a new one in the same place with proper reinforcement. Rebuilding the shaft collars and surface plants was not so hard and only required time, but the underground drifts, galleries and other workings were a different matter. It was very difficult to get to them, the pit bottoms being wrecked and buried and most of the mines being flooded. Clearing the shafts and pit bottoms to approach the drifts was really a heroic achievement.

But pumping out the water was an even tougher job. The few mines that were set apart and were not connected with others contained only 1-1.5 million cubic metres of water. But the big collieries with interconnecting galleries had become huge reservoirs with tens of millions of cubic metres of water. To get at the headings, this immense reservoir had to be drained. If the water had been poured into a surface depression, it would have formed a lake 10 kilometres long, 2.5 kilometres wide and 20 metres deep—a lake fit for sea-going vessels.

The trouble was that the water had to be pumped out through narrow openings in the shafts. All the draining equipment, including vertical pumps with a delivery of 300 to 400 cubic metres per hour, was lowered from the surface through openings ranging from 1.5 to 3 square metres.

The drainage work was costly and consumed a great deal of electric energy. In the first months following the Nazi retreat work was hampered by power shortage, but by the spring of 1944 the problem was solved thanks to the installation of the first 50,000-kw. turbine in the Zuyevka Power Plant and the commissioning of two electric stations on the Kamenka and Northern Donets.

In the early stages of the restoration period, effective use was made of powerful vertical pumps. They occupied

little space and were easy to lower through the shaft neck by cable wound with an electric winch. Ordinary horizontal centrifugal pumps with a capacity of 100-150 cubic metres of water an hour were also employed.

The Donbas miners displayed great ingenuity and skill in restoring the pits. But for their initiative and inventiveness in devising new methods, the coal fields would not have been revived so rapidly.

Their methods were most varied. One of them was to draw water from a mine at a higher level into one at the lower level. In this way they were able to concentrate the pumps at fewer places and drain water at a faster rate. Another method was to channel water from a mine to a deep gully through a horizontal tunnel. In some cases, the need for pumping was eliminated by draining water into absorbent layers of porous bedrock through drill holes. Unfortunately, this method could not be applied everywhere, for not all the mines were cushioned by absorbent bedrock.

An effective method, used widely and called "the air-lift," was to remove water with the aid of compressed air. Powerful compressors were used for this purpose. Dipping water from the mines with steel skips, used as ladles, also proved helpful.

Draining the mines was not the only problem. In many of them, flooded for more than two years, the walls of the passages had sagged and crumbled, clogging the entries and drifts for hundreds of metres at a stretch. It was very hard to clear the rock away, for this was a job that could not be mechanized.

In planning the rehabilitation of the Donbas, we had to decide which mines were worth restoring, and in this respect gave consideration to certain basic factors. In the first place, it was necessary to determine whether the mine had enough coal for at least five years. We also had to determine the extent of damage in each case, the extent of the

flooding and, consequently, the amount of water to be pumped out, the length of the drifts and headings, the firmness of the walls and ceilings, the grade of coal in the mine, and, finally, the amount and type of machinery and equipment immediately available for restonation work. The mines thus selected for restoration were divided into two groups. The first, which was to have priority, included those that were dry, or were very little flooded, and could therefore be repaired easily and quickly. Also in this group were the mines capable of yielding the greatest amount of coking coal. Mines that were badly damaged and flooded made up the second group.

The idea was to restore pre-war production capacities as soon as possible. Therefore, the first step was to repair mines that did not require substantial reconstruction. Very soon the Donbas was again sending out trainloads of coal.

Though no great improvements were introduced in the mines at first, rehabilitation was carried out on the basis of modern technique. While making the best of the old equipment and technological methods, the pitmen improved mining techniques, reorganized certain stages of the work and eliminated the drawbacks of the old system. The main trend was to mechanize the most laborious processes. Labour organization was improved by a more thorough co-ordination of mechanical operations. More rational and effective methods were introduced in haulage, hoisting, preparation, storage and loading.

Seeing the fine results of their labour, the miners worked with mounting enthusiasm. They cleared away the ruins and rubble at the shaft tops, erected headframes, installed hoisting machines and ventilators, equipped the coal-handling platforms and preparation plants and set up temporary surface structures and other technical facilities. The collieries, so important to the country, came back to life one after another.

The papers were full of reports about the heroic efforts of the Donbas miners. To salvage equipment, they sometimes had to work waist-deep in icy water. In the Felix Kohn Mine, no work could be done until pipe-lines under water were connected. A locomotive driver by the name of Doroshenko volunteered to do the difficult job, and did it very well. In the flooded Kalinin Mine of the Artyomugol Trust, some young mechanics dismantled a pump in cold water and brought all the parts out. One could cite any number of such feats.

The miners had only the equipment at hand with which to put the mines back into operation, so success depended largely on their resourcefulness and initiative. To make good the shortage of tools and materials they assembled machines from the parts of damaged ones. Work at the mines that had to be restored first was speeded up by bringing all the equipment available in the other mines. In this all-important job, the miners were well assisted by Party organizations and scientific institutions.

The original programme for 1944 (the first year after the liberation of the Donbas) was to restore 94 key mines with daily pre-war output of 62,000 tons. Although this was a big job in war-time conditions, the miners, inspired by the Soviet Army's victories, undertook to restore another 25 mines, with an estimated daily capacity of 13,250 tons, over and above the plan. The 119 collieries which the miners intended to put back into operation by the end of 1944 supplied 75,250 tons of coal a day before the war. The difficulties the miners encountered did not daunt them. On the contrary, they seemed to spur them on and that is why, I think, they succeeded in doing within a few months what would have taken years to do under different circumstances.

Reconstruction work proceeded at a fast pace, and by mid-1944 there were 17 basic mines and 460 small ones built anew or restored. Towards the end of the year they were producing over 31,000 tons a day. It is interesting to

note that the whole Donbas produced as much in 1902, when average daily output was in the vicinity of 30,000 tons.

For curiosity's sake I would like to compare the tempo of this restoration job with that following the Civil War, when the damage to be repaired was not so great. The job that had taken almost four years after the Civil War was accomplished in 1944 in six months, that is, nearly eight times faster. It was with similar speed that rehabilitation proceeded after World War II in other fields of the national economy. A few months after the launching of the restoration programme, the Donbas was already yielding 13 per cent of pre-war output.

The restoration job successfully begun in 1944 was later continued on a higher technological plane. At first, when the uppermost task was to satisfy the country's urgent need for coal, little thought was given to the future. But later the reconstruction of even the smallest mine was viewed in perspective as part of the over-all plan for the rehabilitation of the Donbas, and full use was made of the latest achievements in mining.

A thing that needs to be stressed again and again is that the Donbas could never have been put back on its feet in so short a time and with relatively little equipment, material and manpower had it not been for the assistance of the mining research institutions in the Ukraine, as well as in Moscow, Leningrad and elsewhere, which resolved the various problems cropping up in the course of rehabilitation.

We held innumerable meetings to discuss different proposals on restoration and decide which methods were most expedient, economical, and capable of producing the quickest results. The technical solutions stemming from these debates and the selfless, enthusiastic efforts of the miners bore wonderful fruits.

Practically every problem was solved with the participation of scientists. That was quite natural because the matter was not one of merely restoring the mines, but of

modernizing them to ensure greater output in the years to come.

The choice of the most advisable draining methods, the most efficient machinery and the best ways of expanding the power industry and increasing coal output—these and many other vital problems were solved on a strictly scientific basis. That, of course, was the only right way of doing it.

At the beginning of the restoration period, these problems were tackled on a comparatively small scale, but in the latter phase far-reaching projects were drawn up with the idea of building up a new, really advanced coal industry. This called for the systematization of an enormous amount of theoretical and experimental data, which had to be carefully considered and weighed. Conditions for the rehabilitation of the Donbas were so unusual that bold, sometimes extraordinary, technical solutions had to be sought. But the problem was solved through close collaboration between researchers and miners.

The former concentrated chiefly on the most rational way of reconstructing the big collieries (that is, the most difficult job) and on planning new ones. This was essential for the planned expansion of the Donbas coal industry.

In the second phase of rehabilitation, the reconstruction of big collieries and the building of new ones proceeded along new lines. Where coal was brought to the surface in cars or ordinary cages, shaft-house facilities were so constructed as to mechanize the further movement of the coal in self-rolling cars, or with the aid of winches operated by centralized control. The handling of coal was automatic, and even the caging and decaging of coal cars was done by mechanical pushers. In big collieries, train movement was regulated from central control points. In mines where coal was hauled to the surface in dump-cages or skips, it was further transported in measuring bunkers with signal devices indicating the coal level. From the bunkers it was carried by belt conveyors.

Close attention was paid to the proper sizing of coal. Preparation plants were equipped to sort coal quickly according to size, ensuring the most effective burning.

Our industry attaches increasing importance to the efficiency of burning fuels. Before the war this matter was not given sufficient attention. After the war, with the damage to our national economy repaired and the country making big strides forward, wasteful burning of Donbas coal could not be tolerated. To provide greater facilities for grading coal, it was necessary to build new preparation plants in addition to restored old ones.

The solution of this urgent problem expedited rehabilitation. Another contributing factor was the experience accumulated by miners in concentrating coal and the research done in this field by scientific institutions and planning agencies. We also made use of methods applied abroad. We never hesitated to draw upon the experience of foreign researchers, which in this particular instance produced good results.

Particular attention was given to the proper utilization of both graded coal and coal silt and other by-products obtained in the process of concentration. In this respect even modern, highly-mechanized coal plants are not always as effective economically as they should be. Many valuable by-products are not used to the extent they should be.

In working out rehabilitation plans and technology, we sought to make the best use of the by-products of concentration. The railways, for instance, were supplied with fuel mixtures produced at the central preparation plants built near the biggest collieries. These highly-mechanized plants had blending, briquetting and sorting shops, and in addition to locomotive fuel mixtures produced pulverized fuel and sifted coal for gas-generating plants.

Reconstruction of preparation plants was of great economic importance and much work was done in later postwar years to rationalize concentration and reduce its cost.

In the second and final stage of the restoration programme attention was focussed on surface arrangements, such as transport facilities, with a view to speeding up coal deliveries. The surface arrangements of a modern colliery, which are becoming increasingly complex, are fairly well mechanized and automatized. All this was taken into account when planning the rehabilitation of the coal fields. The object was maximum mechanization of surface transport, storage and handling facilities. In designing structures, engineers saw to it that they were simple, convenient and light. More overhead ropeways were installed. There had been comparatively few of them before the war, but they proved to be effective, and there are many of them in use in the Donbas coal fields today.

Stationary equipment was modernized and the standards of winding machines were revised and reduced in number with a view to using each type of machine on a larger scale. The efficiency and aerodynamic qualities of axial ventilators were improved through certain changes in their construction.

The manufacture of better and more compact winding ropes of special quality, and of wire cable with greater tensile strength, was another problem that received a good deal of attention.

Extensive mechanization of mining operations, both underground and surface, ushered in a new phase in labour organization. Improved mining methods were introduced in the big renovated collieries. The length of working faces was determined more rationally, and more consideration was given to devising economical roof-control methods and speeding up the rate of advancing the drift stope. Roof-control of the stope is a key problem on which all-round mechanization of all the laborious mining and hauling operations largely depends. It is a problem that has yet to be fully solved. At that time the method was improved through introduction of portable steel props at the biggest collieries.

The main mining operations were bettered by introducing all-round mechanization. Several new types of mining machines had been designed just before the war. They were tested before the war ended, and inventors got busy designing new models. One of them was a coal-cutter operated by remote control. This was an advance to automation.

Further improvements were made on those remarkable machines known as coal combines, which first appeared before the war. It is a triple-operation machine which kerfs the seam, hews coal and clears it out of the stope by conveyor. We take pride in the fact that the coal combine originated in our country. After the war, designers and experimenters worked on new models, and also created loading machines.

The underground haulage system was also reconstructed, and some of the big mines began using 3-ton cars. Such cars, however, are not widely used because they require extra-large and powerful electric locomotives, for which collieries have no particular need.

Much was also done to mechanize the less important operations, such as handling timber props, switching tracks, opening and shutting ventilation doors, etc.

Large-scale automation was out of the question during the reconstruction period, but work was nevertheless started on installing automatic blocking, signalling and dispatching systems.

All these facts show that the Donbas rehabilitation programme was drawn up with a view to planned development for many years to come. The idea was to restore the old collieries and build new ones on a fundamentally new technical basis, one radically differing from the lines along which the Donbas developed before the war. Measures to rehabilitate the Donbas were carried out with due regard to the main requirements of the socialist form of labour organization—improving working conditions and lightening the miners' labour, increasing the capacity of the mines and raising labour productivity. These problems are still

essential, but in the restoration period they were of particular importance. The engineers, technicians and researchers, as well as the thousands of Donbas miners, had to exert the greatest effort and display much resourcefulness to solve them.

The rehabilitation of the Donbas is a glorious page in the history of our mining industry and working class. The job was completed within a few years, with the result that the Donbas was producing more coal than before the war. It was a feat of momentous significance, testifying to the inexhaustible potentialities of the socialist system. To me, a veteran scientist, it is highly gratifying to realize that I, too, made a modest contribution to the fulfilment of a task of vital national importance, and that I was a witness of the wonderful victory achieved by the Donbas miners.

AFTER THE WAR

The development of the Soviet coal industry after the war has been distinguished by a series of far-reaching measures climaxing, as it were, the achievements of the preceding years.

Both before and during the war mining practice and theory made notable headway, but some important problems of the mining, transporting and processing of coal had yet to be solved if the country's steadily growing industrial requirements had to be met fully. Although much attention had been given before the war and immediately after it to over-all mechanization of coal mining, manual labour was still in evidence in some of the essential operations. Loading, roof-control, delivery of timber and propping were not mechanized at all, while some of the other operations stood in need of further mechanization. Therefore, the next step towards increasing coal output and raising labour productivity was all-round mechanization, with emphasis on operations hampering progress.

The post-war Five-Year Plan of National Economic Rehabilitation and Development (1946-50) set the Soviet coal industry the task of increasing output by more than 50 per cent. Annual output was to be raised to 250 million tons by the end of 1950. Though no easy task, it was, nevertheless, carried out very satisfactorily.

The most toilsome job in the driving operation is to load the coal on to a conveyor at the working face. While much of the other hard work was done by machines, this was still done by hand. Before the war, engineers and researchers started designing a loading machine for use in longwall advancing. It was to be used in combination with a coal-cutter, and its purpose was to load coal after it had been broken down (usually by blasting). It took a very long time to construct a loader that was really dependable, serviceable and suitable for wide use in our collieries. The snag lay in breaking coal into hunks that could be handled by the loader. Several types of loading machines were designed in Britain during the war, but the tests failed to produce the desired effect.

After the war our engineers and constructors succeeded in devising some fairly efficient types of loaders with devices, which crushed coal into lumps convenient for transportation. Among these were the NM-1 and VPM models patterned after the coal-cutters of the GTK-3M and MV-60 types. The loader, operating at a short distance from the cutting machine, shovels coal on to a cross conveyor running parallel with the coal wall. It is usually a scraper conveyor, or one of the low-set, bottom-loading types which is more durable and reliable.

We had a good deal of trouble with the early loading machines because they were rather complicated and bulky and required a large unpropped room to work in. Later the machines were improved and widely used in the coal fields.

A further improvement of the loading process came with the introduction, a few years ago, of several new types of the so-called self-loading scraper conveyors designed by

Soviet engineers. These conveyors were placed alongside the coal wall after it had been kerfed by a cutting machine, or else prior to kerfing, in which case the coal-cutter moved along the frame of the conveyor (that, incidentally, is why it was called an "armoured" conveyor). The face of the seam, undercut to a definite length, was then blasted and part of the broken coal (30 to 50 per cent) fell right on to the conveyor. That left a much smaller amount of coal to be shovelled by hand.

The main purpose of building efficient loading machines for use by the method described above was fully to mechanize coal extraction so as to eliminate the basic manual operations in this phase and thereby considerably raise labour productivity. The creation of such machines marked another important step towards all-round complex mechanization. Another step, no less important, was the introduction of coal combines.

The invention of these highly productive, multi-purpose machines was a notable achievement of Soviet science and engineering. Several types of combines are now used abroad, but we are nonetheless proud of the fact that it was our country which first produced such machines and that their quality is superior to foreign models.

The appearance of the combine marked a new stage of development in the Soviet coal-machinery industry and mining technology. Our engineers made scores of tests before they developed the most productive and economical type of coal combine. A tough problem on which they had worked since 1941 was that of constructing an efficient and dependable mechanism for cutting coal.

Some of the early models were modernized coal-cutters with several straight cutting bars, or a combination of straight and curved bars. In certain cases annular bars were used. A set of these bars, put into action by two or three coal-cutters placed one on top of another, make a number of intersecting horizontal and vertical slits which divide the face layer of coal into so-called benches. To

break down the benches, or to loosen the seam when coal is soft or of medium hardness, a long-toothed revolving bar is used, which also has one or two cutting bits for making additional slits. At the end of the bar is a shear-jib for separating undercut coal from the rest of the seam.

Several types of coal combines constructed along these lines were manufactured after the war, and proved highly efficient. The VOM-2 combine, made soon after the war and known as a cutting and stoping machine, was of original design. It was intended for use on longwalls of 50-60 metres in width, like those often seen in the mines of the Moscow Coal Basin. Combines of this type are well suited for working soft seams. After being kerfed and slit into benches, coal breaks into pieces of easy-to-handle size. Modified combines for working flat and inclined seams were designed to break coal off a longwall in small sections not exceeding two metres in breadth.

Not all the types of machines were equally good or efficient, but they testified, at any rate, to steady improvement, and also to the high standard of Soviet mining research and engineering, which within a short time solved problems that could not have been tackled before the war, or, if tackled, would have taken much time and effort to solve.

In the years immediately following the war, rapid progress was made in the designing and manufacture of machines for the coal industry. Many of them were of original design.

A competition for improved types of mining machinery and equipment was held in 1947. It was gratifying to see that a good number of those who took part in the competition were engineers and technicians employed in the mines. Quite often they "corrected" what we theoreticians proposed, and most of the ideas and schemes they suggested were used in designing new machines. This was further evidence of close co-ordination of theory and practice in our country and the benefits of sharing experience and know-how. Every new indication of this delights us vet-

erans of the mining industry, who well remember how different things used to be in the old days.

One of the finest machines designed shortly after the war was the so-called coal-plough, which shears coal off the face of the seam in sizable lumps and loads it on to a conveyor.

The machines I have mentioned helped to mechanize basic mining operations, particularly cutting, hewing and stoping. But after the war more attention was given to mechanizing development work—a most arduous job. Among the new machines in this field were devices for loading coal and rock, and heading machines for driving drifts. Drift mechanization increases coal output considerably.

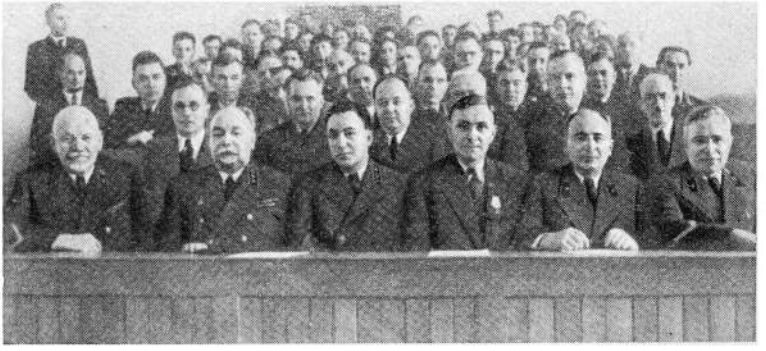
Another step towards fuller mechanization is the designing of portable propping devices for supporting the roof of the drift stope in which men work at the coal face. Propping is very hard work and requires a lot of timber. So the urgent problem is to devise reliable bracing, something in the form of a roofed steel gallery that could move automatically as the heading advanced.

We know from experience that this is a very hard problem. It takes a lot of money and profound theoretical research to make such galleries. An effective method of roof-control in the stope would complete all-round mechanization of coal mining, make the work of the miners safer and easier, and further raise the productivity of their labour.

All-round mechanization must needs be combined with the development of more effective mining methods. Not until then will labour productivity be raised to such an extent as to ensure a substantial reduction in the number of men employed in the mines.

The development of more rational mining methods is one of the major problems on which coal experts have been working for years, and which cannot be considered solved as yet.

The thin and medium coal seams in the Donbas are bedded in unstable side rock, earth displacements, and often dangerous for their gas and dust. In such conditions it is neces-



Academician A. M. Terpigorev among the teaching staff of the Dnepropetrovsk Mining Institute

sary to maintain the longwall and pillar mining methods in combination with new types of machinery designed completely to eliminate the most arduous manual labour in the stopes.

Broadening the breast is a vital factor for raising labour productivity, and it is easiest done in the longwall method. The trend to broaden the breast is perfectly justifiable, for while it may somewhat slow the average speed of advancement, it increases the miners' efficiency.

Complete mechanization of coal extraction requires the reorganization of other operations, especially hauling. A good deal has been done here since the war. Capacious cars of three, four and even five tons are used in big collieries, and smaller mines use one- and two-ton cars. Coal trains in the main roadways are hauled by powerful Soviet-made electric locomotives.

Thanks to extensive mechanization, coal output in the Soviet Union is rising from year to year—it is 19 times that of 1924. Labour productivity has increased almost 50 per cent over pre-war. Had the mining operations been mechanized piecemeal, and not as a co-ordinated whole, the industry would hardly have made such notable progress.

The problem has been fundamentally to re-equip the industry on the principle of integrating separate machines and devices in a single mechanical system.

Mechanization of the basic operations—kerfing, hewing, hauling, handling and loading—was completed in 1950. This was a big victory for the Soviet people and cleared the way to a higher phase of over-all mechanization, covering every process right to the loading of coal into railway cars. To attain these higher standards of mechanization, the coal industry is gradually replacing coal-cutters by combines, devising mechanical propping installations and using rock-loading machines in development work.

Manpower is being gradually replaced by machines. The very nature of miners' labour is changing; they are acquiring new skills and trades—skills and trades which first appeared 10-15 years ago. Some operate coal combines and other machines, others work as mechanics and electricians.

All this has helped to improve labour organization in the collieries and to switch to more up-to-date and effective methods. One of them is to mine coal in a continually recurring cycle. Experience has shown that such methods are highly effective in raising coal output and help to turn our mines into model socialist enterprises. Thousands of longwalls in our mines are being worked according to the "continual-cycle" schedule. It has proved at least 50 per cent more effective than the ordinary method.

I would like to emphasize again that in our country science plays a great role in improving labour organization in mining and introducing all-round mechanization. In the past twenty years much valuable research has been done into the physical and mechanical properties of bedrock, ways of separating coal from the rock, and methods of crushing rock and earth with the working parts of mining machines. The treatment of these problems has developed into a new branch of mining science. The working parts of the excavating machine are designed to work upon rock or minerals of specific hardness and structure. In one case

the rock is separated from the massif by cutting, in another by drilling, in a third by chipping, and so forth. Hence, different approaches are needed to testing the performance of different mining machines.

Our researchers are doing a job of great practical and economic importance in experimenting with the breaking of bedrock by hydraulic methods. This method of extracting coal has been used with marked success in one of our mines.

Another important mining method is blasting, especially in the extraction of ore and breaking of very hard rock. Researchers in this field, experimenting in controlled blasting and studying ways of increasing the power of explosives, are making good progress. Particular importance is attached to research aimed at greater safety for miners working with explosives.

The present trend of modern technique in breaking down different kinds of hard-earth structures (ore, rock, coal, etc.) gives room for hope that a unified theory on the breaking down of all types of strata will soon be developed. This will be of great help to mining. The research done by academic, industrial and educational institutions is co-ordinated by the U.S.S.R. Academy of Sciences, and the findings are periodically turned over to the industry.

These studies are related to another important problem which has been posed by the Mining Institute of the U.S.S.R. Academy of Sciences, and on which the Giprouglemash Research Institute for Developing Mining Machinery has been working successfully for the past several years. The problem is to construct a complex, automatically-operated assembly line which would include a mining combine, a coal-face cross conveyor and a mobile mechanical propping unit. Several types of such an assembly line have already been tested, and the results are quite good.

Haulage facilities have an important bearing on labour productivity and their further improvement is an urgent problem for mining researchers and engineers. The electric locomotives in our collieries are chiefly of the trolley type.

We do not use diesel locomotives (as it is done in Britain and the United States) because they pollute the air, so it is unlikely that we will do any research in that direction. Instead, we have designed electric locomotives of the condenser type with an alternating current intake. They eliminate loss of power from the conversion of alternating current into direct current.

Research institutes of the coal and ore mining industries are working to improve transport systems. Among other things, they are devising signalling and interlocking devices, automatizing the control of switches, winches and pushers at loading points, and converting pumps, ventilators and compressor plants to automatic control.

Remote and automatic control of conveyor systems is already in wide use in Soviet coal fields and steps are now being taken to apply telemechanics to underground haulage. It is a problem that will no doubt be solved in the near future. It is equally important properly to organize surface transporting and handling operations, since they account for a big share of the heavy work involved in coal mining —as much as 24 per cent in the Donbas in 1951. Mining researchers are now working on standard equipment and arrangements for rationalizing surface operations. Their objective is to simplify surface arrangements and fully to automatize all handling and transporting operations, from the hauling of coal to the shaft collar to its loading into railway cars or delivery to the preparation plant. The ultimate purpose of all this research is substantially to raise labour productivity. It is rising in our country at a much faster rate than in capitalist countries. In the 12 years ending with 1940, the efficiency of labour in the Soviet coal industry more than doubled. Our coal miners' efficiency is much higher than in any of the European capitalist countries and is excelled only in the bituminous mines in the United States. Nevertheless, labour productivity still lags behind the growing requirements of our national economy and is not yet equal to the problems facing the Soviet coal in-

dustry. At its Nineteenth Congress, the Communist Party of the Soviet Union stressed the need for raising labour productivity by approximately 50 per cent during the current five-year plan period. That, of course, concerned miners too. Success depended largely on the over-all achievements of the scientific institutions engaged in mining research.

Further measures towards developing the coal industry and increasing its output were outlined by the Party at its Twentieth Congress. As in the past, the Donbas plays a major role in satisfying the country's fuel requirements. It is planned that the Donbas output will reach 212 million tons in 1960, that is, exceed the 1955 figure by 77 million tons or 57 per cent. Output in the Kuznetsk, Karaganda and other coal fields in the eastern parts of the country is to be substantially increased so as to curtail sharply the transportation of coal over long distances. Moreover, provision has been made to develop the Donbas coal fields at a still faster rate. This will require a larger supply of modern, powerful machinery. The day is not far off when mine labour will be mechanized and lightened to the utmost.

The Soviet coal industry has advanced tremendously in the past decades—to a point beyond the boldest old-time dream. Since I have witnessed all these changes and remember what the situation was like in tsarist Russia, I would like to let my imagination wander a little and try to predict the morrow of the Soviet coal industry.

Mechanization and automation of our collieries, I imagine, will turn them into veritable underground factories. The machines and devices in a colliery will be automatized and controlled from a panel on the surface. Combines will hew coal and load it automatically on to a conveyor running along the working face. The conveyor will carry coal to the main roadway and discharge it into mine cars. A steel roof-supporting frame will move automatically into the face-working room created by the removal of coal. Electric locomotives will haul cars of coal to the pit bot-

tom, where they will automatically discharge their load into bunkers and return for the next load. Also automatically, the bunkers will discharge coal into skips that will be hoisted to the surface. There, at the shaft collar, coal will be dumped on to conveyors and the latter will empty their load into railway cars.

The central control panel will be outfitted with all sorts of regulating and measuring instruments, a screen showing the location of various underground machines, and an automatic counter that will register the number of cars of coal or rock brought to the surface. The controller will be in constant touch with the underground workings by radio. Varicoloured signal lights on the panel will keep track of the operations. A green light will show that everything is going smoothly. If a red light flares up, he will immediately communicate by radio with the operator at the coal face and find out what the trouble is.

The controller will not have to go down the shaft to see how the haulage system is working. The screen on the panel will give him the exact picture. Dotted lines on the screen will enable him to follow the movements of the coal train. Automatic instruments will keep track of the operation of the pumping and ventilating systems and react instantly to the slightest deviation.

It is a remarkable feature of Soviet reality that the boldest of dreams come true faster than we can imagine. The colliery which I have just pictured will be a reality in the near future—sooner than it may seem now. I hope to live to see it, and I do not think I will have to wait so very long.

ASSOCIATES AND FRIENDS

I would like to mention some of the scientists, engineers and directors of various institutions whom I have met, and with whom I have associated in the fifty-odd years I have worked in the coal industry.

One of my closest associates and friends is Professor Mikhail Pavlov, now a member of the Academy of Sciences. I first met him in the Pastukhov Ironworks in 1897. He had just returned from a trip to America where he went to study metallurgy, particularly production of pig iron in blast-furnaces using anthracite. Pastukhov also ran his ironworks on anthracite. In 1900, Pavlov and I were invited to teach at the Yekaterinoslav Mining Institute; his subject was metallurgy and mine, mining. In 1906, Pavlov was appointed professor at the St. Petersburg Polytechnic Institute. Now, when I recall the times we worked together, I think I was always guided by Pavlov's clear and well-defined views. He was held in high esteem by the younger instructors, and his ways of working and ability of thinking in broad terms greatly influenced the moulding of engineers and teachers.

As a mining specialist, and later as a teacher, I was closely connected with Professors Boris Boky and Alexander Skochinsky of the Leningrad Mining Institute. Professor Skochinsky, now an academician, and I are about the same age; we began teaching and took our Adjunct of Science degrees at the St. Petersburg Mining Institute at about the same time, and for many years worked together, mostly in the Donbas. We worked, travelled, argued and investigated, always with a feeling of mutual understanding and respect. Our association was so close that our approach, our system, and even the order in which we did things, grew to be much the same. We frequently investigated problems together and then, after discussing them, arrived at joint conclusions. This method has always been fruitful and we still adhere to it.

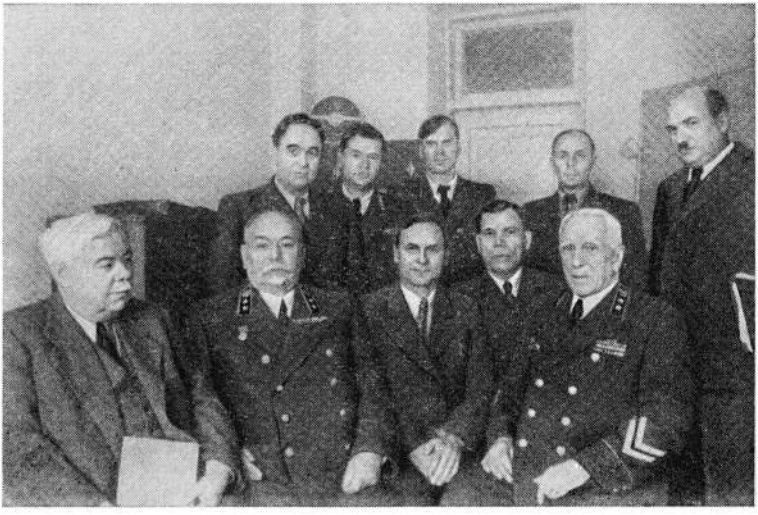
We have collaborated for 55 years in improving the coal industry and advancing the science of mining. Our close friendship has often been made a subject of cartoons and limericks. Sometimes our fellow-workers joke behind our backs, thinking that our sight and hearing have so deteriorated with the years that we do not notice it. But

we do not mind. At the Mining Institute of the U.S.S.R. Academy of Sciences we are known as "the black old man" and "the white old man." And although I am now more grey-haired than black, the nickname has stuck. The 55 years of our association have never been marred by discord.

A fine person I often think of was the late Professor Mikhail Protodyakonov, with whom we worked in harmony building up the Yekaterinoslav Mining Institute. At first he was my assistant. At the time we worked together, he made a thorough study of the problems relating to rock pressure and mine-propping and wrote his well-known two-volume monograph on the Donbas coal fields. Together we did research on safety techniques in the Donbas and investigated the application of advanced mining methods in Central Asian coal fields. We also collaborated in many other fields.

Protodyakonov's marvellous capacity for work and the thoroughness with which he did everything are an excellent example for the younger generation to follow. His affability and frankness, his good-natured irony and humour imparted a peculiar charm to his manner of speech. I always liked the way he treated students. He was always patient and amiable, but very strict and demanding at examinations.

For more than forty years now I have been working with my close friend, Lev Shevyakov, once my pupil and now an academician. The thoroughness with which he studied and upheld his graduation thesis at the Yekaterinoslav Mining Institute, and his independent way of thinking distinguished him from the other students. At my suggestion he was taken on as a senior instructor in my chair. He was immediately put in charge of collecting and systematizing data for the second volume of the monograph on the Donbas. Here he showed himself to be a researcher fully capable of analyzing and criticizing independently the complex material he was working with. This urged me to entrust him with writing some of the articles for the monograph.



Academicians A. M. Terpigorev and A. A. Skochinsky among the participants of the Conference devoted to the coal industry, Donbas 1953

Shevyakov's brilliant presentation of his thesis on analytical problems concerning the stripping and winning of coal beds in the Donbas, won him the degree of Adjunct of Science and the title of professor. He succeeded me at the mining faculty when I left Yekaterinoslav for Moscow.

I must also say a few words about Ivan Gubkin. He was Rector of the Moscow Mining Academy when I began teaching there and soon offered me the job of dean of the mining faculty, and a year later, the post of pro-rector of the Academy in charge of curricular matters. In that capacity I was Gubkin's immediate assistant until the time the Academy was divided into separate technical colleges.

During the eight years that we worked together, Academician Gubkin and I discussed and settled many problems. Together we organized research work in industry and,

in particular, in the Kursk Magnetic Anomaly. We went there frequently to inspect and to hold meetings.

Though quite an important personage, Ivan Gubkin displayed amazing patience and modesty when discussing various questions. He always listened attentively to what others said, debated controversial points, and readily agreed with his opponents if their arguments were convincing. But if he thought them false or wrong, he held his ground with fierce tenacity. Any shiftiness or inclination to confuse an issue instead of taking a definite stand, angered him and made him reticent. By and large, however, he was a person of easy disposition, unassuming and frank. He was energetic and always ready to help in any matter, if he believed in it. Endowed with these qualities, he knew how to create a friendly and informal atmosphere for his associates. I always had a warm feeling for Ivan Gubkin, and was grateful for the opportunity of working under his guidance, and side by side with him, for so many years.

During my early years at the Moscow Mining Academy I worked with Professor Vladimir Obruchev, later an academician. At that time he was pro-rector of the Academy and dean of its mining faculty. Those were the very functions that later passed to me. Vladimir Obruchev was by then a scientist of world renown and unassailable authority, and we of the younger generation were very proud to have him as a preceptor. He was a quiet and unassuming man, and sometimes even shy of manner. But whenever it came to upholding a worthy cause, he was firm and insistent. Because of his benevolent nature and his constant preoccupation with his scientific pursuits, he lacked the pertinacity of an administrative functionary and for that reason the routine of his administrative office seemed to embarrass him. He was eventually relieved of the troublesome duties of dean and pro-rector at his own request, but retained his chair.

I have mentioned only one trait of Obruchev's character, for I do not have the gift of a writer and I am afraid

Academicians G. M. Krzhizhanovsky and A. M. Terpigorev at an Academy of Sciences session in 1954

that if I were to attempt a more detailed description, it would be drab and uninteresting compared to the many articles and other writings about him that have appeared in contemporary magazines. Our young people know and love him, regarding him as the embodiment of the finest features of a Soviet scientist. At a place outside Moscow, where many of us academicians have our country-houses, not so long ago, he often went out for a walk. A shortish figure in a plain coat and cap, he strode alone, hands behind his back, with the even, unhurried step of a seasoned geological prospector. And in the evening, you could see him at work at his window.

Another portrait that comes to mind is that of the late President of the U.S.S.R. Academy of Sciences, Alexander Karpinsky, a scientist of world fame. He lectured to us, took our examinations, and taught us new

theories on the history of the earth, which revealed so much to me in my younger years. Decades later, I had occasion to meet him again in the Academy of Sciences, at meetings in the Mining Institute in which he took an active part as a mining engineer and geologist. He was rather old then and his health was beginning to fail him, but in spite of that and of his great preoccupation with the Academy's affairs, Karpinsky never missed a meeting of the Council of the Mining Institute, and always had something to add to our discussion of mining and geological problems. We always paid heed to his advice. To us he was not only an unsurpassed teacher and a distinguished scientist whose range of knowledge and breadth of outlook was amazing, but also a personable man, an elder colleague with wide experience. It is many years since he left us, but we remember him very often.

There were other scientists, engineers and veteran Communists with whom I met and associated and whom I regarded as models in my own work as engineer and teacher.

One of them is Gleb Krzhizhanovsky, an old Bolshevik and a member of the Academy of Sciences. In October 1922, when I came to Moscow to teach at the Mining Academy, Krzhizhanovsky was Chairman of the State Planning Commission. He invited me to work in the Commission's fuel department. I had heard a great deal about him, but after talking to him I gained a much clearer impression. Frequent contact with him in various government and scientific institutions in subsequent years had a great influence on me. I admire the effort he exerts for the benefit of our country's economic progress. It was Krzhizhanovsky who opened my eyes to the necessity of always looking many years ahead, with regard to both mining problems, and to the entire range of our socialist state's prospects and interests. We have had many an argument, but they have only strengthened our mutual sympathies and have never been a hindrance to our collabo-

Academician A. M. Terpigorev among the trade-school students. December 27, 1951

ration, which has been going on for over thirty years. I have always regarded Krzhizhanovsky as my teacher, and have gratefully availed myself of his guidance and advice.

I have recalled here only a few of the outstanding people with whom I have worked at different periods of my long life. Had there been more space, I would have mentioned many more, including my pupils who now work all over the Soviet Union. Most of them hold key posts in industry or have won recognition as researchers. I have done joint work with many of them and still do, enjoying their assistance and their advice. I learn from them and, in turn, try to help them with my own knowledge and experience.

I have always tried to make my work part of the collective effort of my associates and students, and of public organizations, and, on the other hand, have always enjoyed their support and encouragement. That is what has pre-

served in me, now that I am eighty-two years old, sufficient energy and vigour to participate in the common cause of building up our new society.

* * *

Having looked through these notes, I wonder whether they should be called reminiscences or an outline of the development of the Russian mining industry, and chiefly of the Donbas. I think they are a combination of both.

At any rate, this book is the fulfilment of a promise I made on my 75th birthday and the 50th anniversary of my work as an engineer, teacher and researcher. Replying to the congratulatory messages from miners all over the country, I promised to describe the development of the Donbas coal fields in the form of reminiscences. That was how the idea of writing these notes originated.

In conclusion I would like to say a few words to the younger generation.

I witnessed the development of our mining industry before the Revolution, I saw its rebirth under the Soviet system, its growth to maturity as a leading branch of our Soviet economy, and I take pride in the fact that I am now witnessing our country's triumphant advance towards communism. What I want to say to the young readers of this book is: "Love your work, put your heart and soul, all your knowledge and ability into it, and above all, never shirk small jobs, for it is small things that make up a great accomplishment. Be true patriots!

"If you love your people, if you link up your whole life with them and give them all your energy and knowledge, the people will respond with love and recognition. That is the conclusion I have drawn from my own life."